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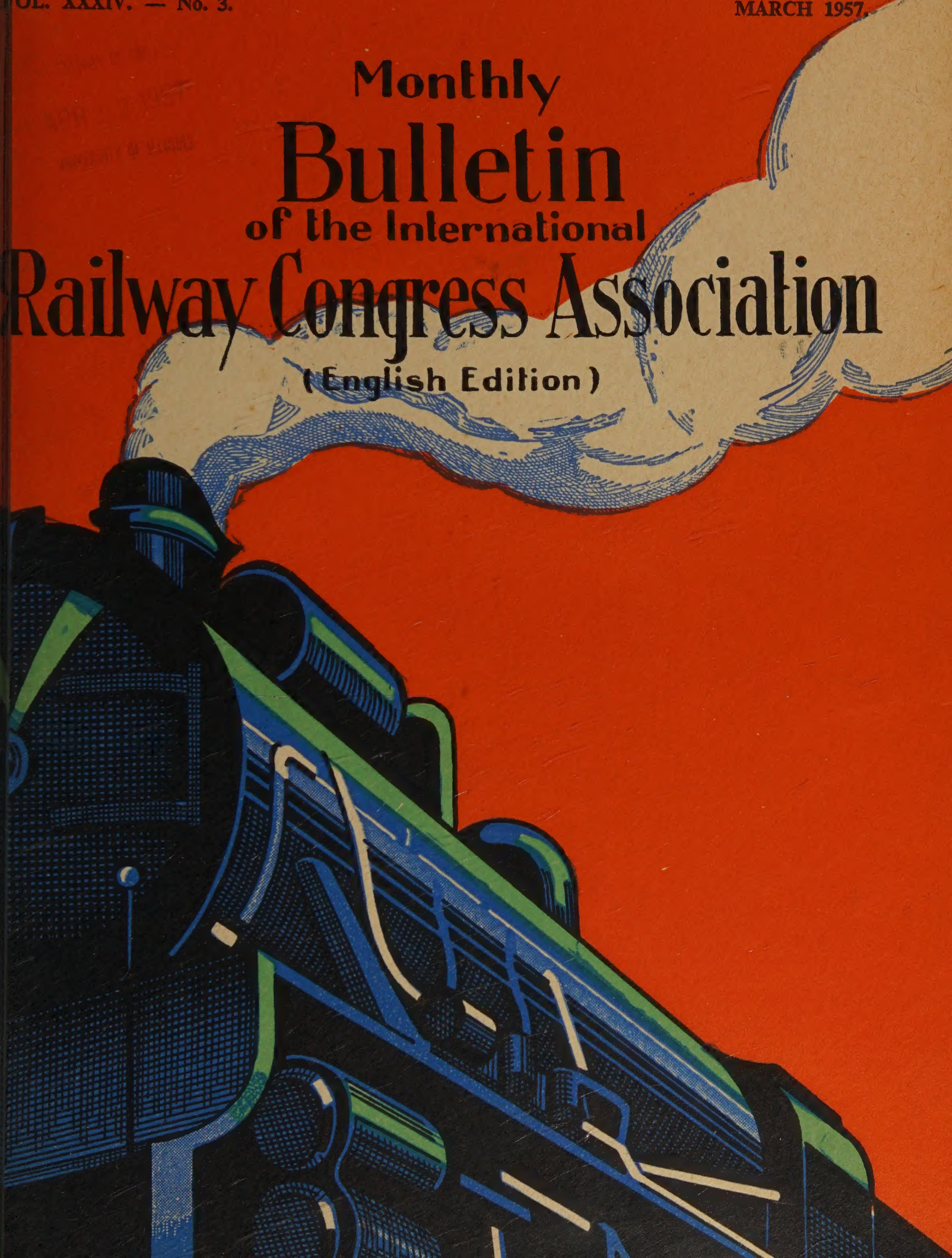
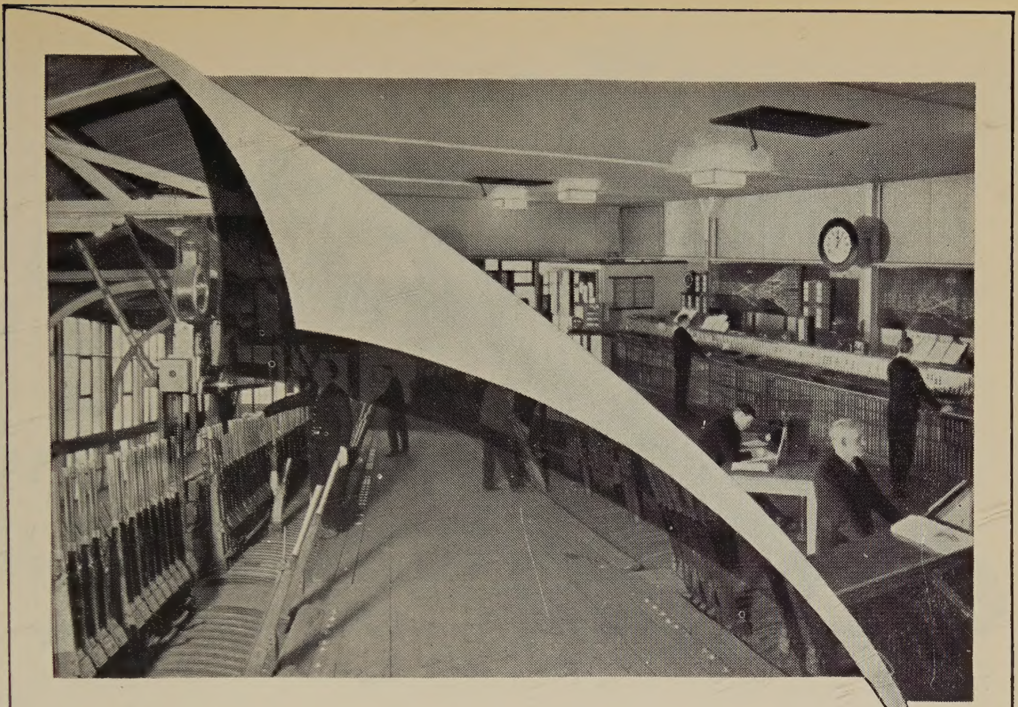
VOL. XXXIV. — No. 3. MARCH 1957.

Monthly
Bulletin
# of the International
Railway Congress Association
(English Edition)





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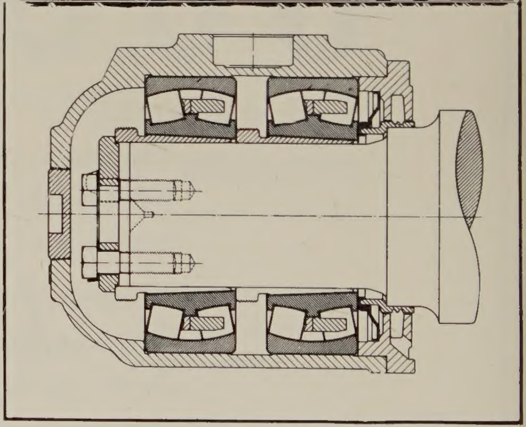

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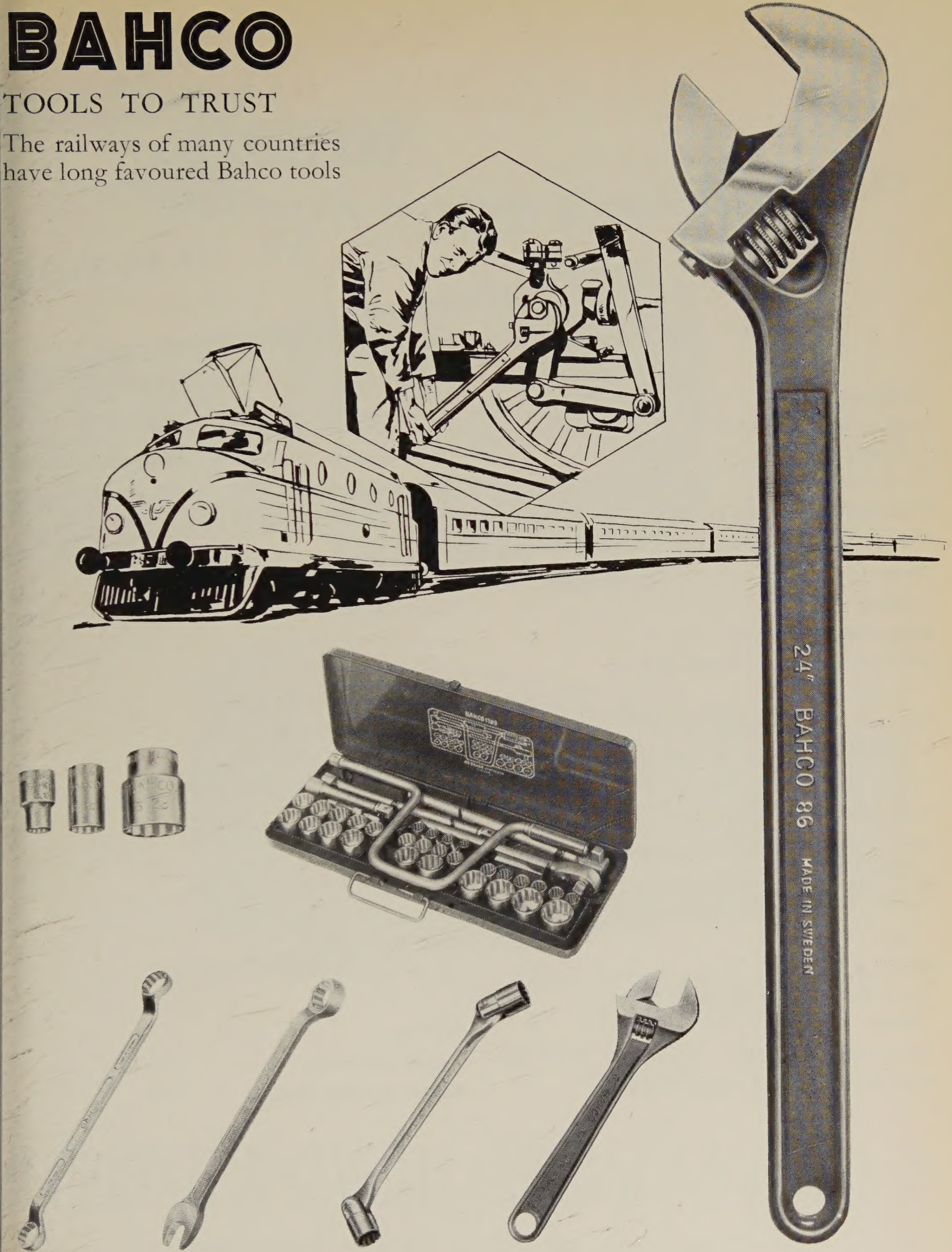

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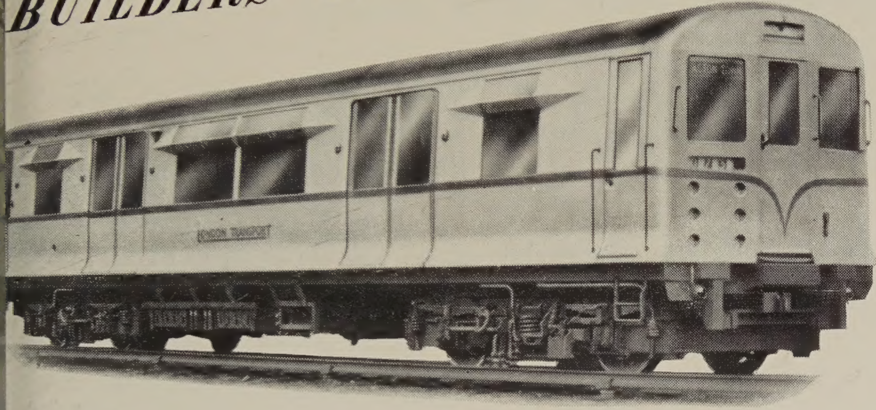

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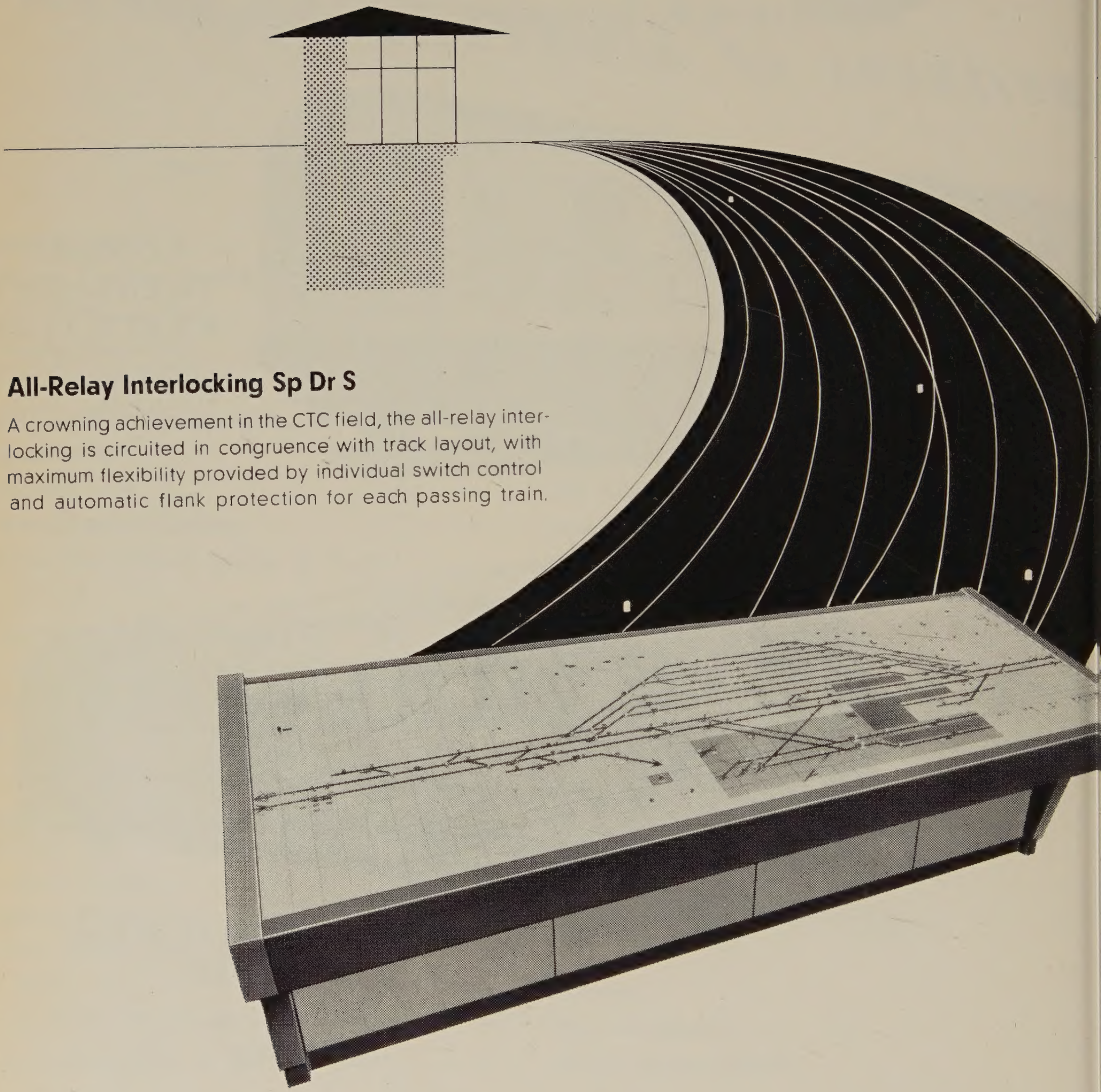

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CONTENTS OF THE NUMBER FOR MARCH 1957.

656 .286
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 189
HORSTMANN (W.). — **Questions of responsibility in the case of accidents at level crossings** (.5 000 words)

625 .14 (01
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 199
RUBIN (H.) — **Resistance to warping of continuously welded old and new rails.** (1 600 words, tables & figs.)

625 .285
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 204
TASCHINGER (O.). — **The technical evolution of the fast automotor trains and the results obtained in service . Exploiting the experience acquired to design the future trains « Trans-Europ-Express ».** (12 000 words, tables & figs.)

656 .215 & 656 .25
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 231
TOLKSDORF (M.). — **The influence of railway lighting on the visibility of signals** (2 600 words & figs.)

625 .25
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 239
The disc brake. (3 500 words & figs.)

625 .151 (42) & 625 .174 (42)
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 248
Oil circulation point heaters on London Transport lines. (1 100 words & figs.)

625 .3 (73)
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 252
Test of monorail line in Texas. (200 words & figs.)

656 .25 (73
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 254
Communications... — in the decade ahead... (1 000 words.)

385 (09 .2
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 256
Obituary — Mr H.D. WARD SMITH (600 words & photograph)

385 (06 (6)
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 258
New Books and Publications. — **Second Conference of General Managers in Southern Africa. Record of proceedings.** (300 words)

625 .13 (45 + 494)
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 258
New Books and Publications. — **Il Cinquantenario del traforo del Sempione 1906-1956** *(The fiftieth anniversary of the Simplon tunnel 1906-1956)*. (400 words.)

385 (09 .3 (45)
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 259
New Books and Publications. — **Le Ferrovie Italiane dello Stato 1905-1955** *(The Italian State Railways, 1905-1955)*. (500 words.)

385 (09 (45)
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 260
New Books and Publications. — **La Gestione di Stato delle Ferrovie Italiane (1905-1955). Monografie.** *(The running of the Italian Railways by the State (1905-1955). Monographs)*. (400 words.)

385 (08 (460)
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 261
New Books and Publications. — **Red National de los Ferrocarriles Españoles. — Memoria del Consejo de Administración. Ejercicio 1955.** *(Spanish National Railways. Report of the Administrative Council Year 1955)*. (300 words.)

385 (09 .3 (675)
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 262
New Books and Publications. — **Compagnie du Chemin de fer du Bas-Congo au Katanga, 1906-1956.** *(Lower Congo to Katanga Railway Company, 1906-1956)* (400 words.)

385 (08 (59)
1957
Bull. of the Int. Ry. Congr. Ass., No. 3, March, p. 263
New Books and Publications. — **Malayan Railway Administration Report for the year 1955,** by C. G. HARRISON. (300 words.)

Note. — This contents sheet is appended to the BULLETIN to be cut out,

MONTHLY BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS ASSOCIATION
(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES: 19, RUE DU BEAU-SITE, BRUSSELS

Yearly subscription for 1957 : **Belgium . . . . 700 Belgian Francs**
Universal Postal Union . . . . 800 Belgian Francs

Price of this single copy : 80 Belgian Francs (not including postage).

Subscriptions and orders for single copies (January 1931 and later editions) to be addressed to the General Secretary, International Railway Congress Association, 19, rue du Beau-Site, Brussels (Belgium).

Orders for copies previous to January 1931 should be addressed to Messrs. Weissenbruch & Co. Ltd., Printers, 49, rue du Poinçon, Brussels.

Advertisements: All communications should be addressed to the Association, **19, rue du Beau-Site, Brussels.**

CONTENTS OF THE NUMBER FOR MARCH 1957.

	CONTENTS	Page.
I.	Questions of responsibility in the case of accidents at level crossings, by W. HORSTMANN	189
II.	Resistance to warping of continuously welded old and new rails, by H. RUBIN	199
III.	The technical evolution of the fast automotor trains and the results obtained in service. Exploiting the experience acquired to design the future trains « Trans-Europ. Express » *(to be continued)*, by O. TASCHINGER	204
IV.	The influence of railway lighting on the visibility of signals, by M. TOLKSDORF	231
V.	The disc brake	239
VI.	Oil circulation point heaters on London Transport lines	248
VII.	Test of monorail line in Texas	252
VIII.	Communications... — in the decade ahead	254
IX.	OBITUARY : Mr. H. D. WARD SMITH	256

CONTENTS *(continued)*.

		Page.
X.	NEW BOOKS AND PUBLICATIONS :	
	Second conference of General Managers of Railways in Southern Africa. Record of Proceedings	258
	Il Cinquantenario del traforo del Sempione 1906-1956. *(The fiftieth anniversary of the Simplon tunnel 1906-1956)*	258
	Le Ferrovie Italiane dello Stato 1905-1955. *(Tne Italian State Railways 1905-1955)*	259
	La Gestione di Stato delle Ferrovie Italiane (1905-1955). Monografie. *(The running of the Italian Railways by the State. Monographs)*	260
	Red National de los Ferrocarriles Españoles. — Memoria del Consejo de Administración.Ejercicio 1955. *(Spanish National Railways. Report of the Administrative Council. Year 1955)*	261
	Compagnie du Chemin de fer du Bas-Congo au Katanga 1906-1956. *(Lower Congo to Katanga Railway Company, 1906-1956)*	262
	Malayan Railway Administration Report for the year 1955, by C. G. HARRISON .	263
XI.	**Centenary of the « Revue Universelle des Mines » (R.U.M.)**	264
XII.	MONTHLY BIBLIOGRPHY OF RAILWAYS	21

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An edition in French is also published.

Vol. XXXIV. — No. 3. March 1957.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656 .286]

Questions of responsibility in the case of accidents at level crossings,

by Werner HORSTMANN.

(*Die Bundesbahn*, No. 22, November 1955).

I

All measures intended to assure safety at level crossings have as their object the prevention of accidents and the safeguarding of the life, integrity and property of individuals. There can therefore be no question of asking oneself what savings can be made on agreed damages by multiplying and perfecting the safety devices and the consequential reduction in the number of accidents. And in fact, the cost of meeting such damages in the case of accidents at level crossings are out of all proportion to the cost involved in increasing safety at such crossings. However the question of responsibility — in other words the question of knowing who is *materially* responsible for meeting the damages — plays an important part in connection with accidents at level crossings. This will be the better understood when it is considered that on the answer to this question may depend the subsistance of the road user involved in an accident. On the other hand, in recent years, road users have sometimes caused damages to the Deutsche Bundesbahn many times greater than the most serious damage ever caused to road users at level crossings.

It is a mistake therefore to think all the time, when considering the question of damages, of the obligation of the railway to pay damages but not of its right to receive damages. This is due to a great extent to the very wide spread idea, which has no foundations in fact, that in the case of every accident at a level crossing the fault lies with the railway and with the railway *alone*. This idea however seems to be due to a great extent to the responsibility of the railway by virtue of the Law on Responsibility (for damages to individuals) and the Law on Responsibility for material damage. These two laws lay down in principle : when, during the operation of a railway, a person is killed or injured, or something damaged, the undertaking must make good the damage if it cannot prove that the accident is due to a case of force majeure, or to the personal error of the deceased, or injured person, of the owner of the damaged property or of the person in actual charge of it.

The obligation to make good, which we are now considering, is founded solely upon the dangerous character of railway operating, quite apart from any error committed. As a general rule, only the one who is *guilty* is responsible for damage. Responsibility *owing to the risk involved* is based on the idea of equity that he who runs an undertaking of *exceptional* danger must be liable for any damage caused by this undertaking.

It is considered that the particularly dangerous character of the railway is due above all to the heavy masses involved, to the high speeds, to the length of the braking distances, to the fixed track making it impossible to avoid obstacles, to its being bound up with a definite timetable and the haste that often results therefrom, and to the crowding due to the transport of large multitudes.

The opinion that holds that the railway is a *particular* danger is now outmoded. The reasons invoked to explain the risk are no longer pertinent for the most part. For example that fact that it runs on rails means on the contrary increased safety for the other users of transport. The permanent way is only used by the railway, so that path taken by a train will be known to the last centimetre and is clearly marked where it crosses over a road. On the other hand, the road is used by many different types of transport, which move as they please and no one can tell where any vehicle or person may choose to go from one instant to another; their routes cross and recross. A comparison of the accident figures for the different methods of transport proves without doubt that the railway is not characterised by any *special* risk but rather by special *safety*.

It is not a question of expressing an opinion on the justification for the responsibility owing to the risk considered in itself. In spite of numerous reasons to the contrary, it can be admitted in principle. In many countries, where the idea of responsibility owing to the risk does not exist, in practice responsibility in the case of error has so evolved that it corresponds more or less to the responsibility in case of risk, the logical consequence of doing away with the obligation to supply the proof due to the fact that the other party is in a difficult position if an error on the part of the railway has to be proved.

What must however be rejected absolutely is any extension of the responsibility of the railway. Whilst the dangerous character of the railway is constantly diminishing on account of its own progress and technical progress in general, as well as the adaptation of the public, the interpretation of the laws on responsibility is becoming more and more biased against the railway.

II

According to the text of the above laws, the preliminary condition of the obligation to make good imposed on the railway is that the accident has taken place in the « working of the railway ». In the sense of and according to the objective of these two laws, the operations habitually associated with the particular risks of railway operating must be considered as due to such operating. But what this covers is often doubtful. In view of the very wide meaning given to the idea of « operating » by the tribunals, the responsibility on account of the risk is often exaggerated.

Unquestionably the movement of vehicles must be considered as dangerous, i.e. contributing to accidents : this is one obvious meaning of operating in the sense of the laws on responsibility. A collision with a moving train — the most frequent type of accident at a level crossing — is therefore indubitably an operating accident in the sense of this legislation. Accidents which occur during the opening or closing of the gates are also operating accidents, as the moving of the gates constitutes immediate preparation for railway operating and is associated with its particular risks (¹). But it is not an operating accident when there is a collision with a closed gate (²); however the contrary opinion has also been maintained (³). An accident due to the condition of the crossing, for example owing to uneveness of the ground, is also not an operating accident.

A clear delimitation of « operating » is however of the greatest importance : as we have already said, an operating accident is the sole condition of the railway having to make good the damage. If on the contrary, there has not been an operating accident, the injured party must, in conformity with

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(¹) Oldenburg Court of first instance, 19th May 1953, MDR 1954, p. 38; Ludwigshafen Court of Appeal, 3rd August 1954.

(²) Hamm Court of Appeal, 29th September 1953.

(³) Königsberg Court of Appeal, VAE 37, p. 568.

the fundamental legal rule when damages are sought, prove that the railway is at fault.

Amongst the motives excluded from operating, the case of « force majeure » can only be touched upon here. « Force majeure » — which is not defined in the law — is according to jurisprudence an outside event of a quite exceptional nature, which from all possible aspects was inevitable. In this connection, jurisprudence lays down such stringent rules that the plea of « force majeure » can in fact never be put forward successfully. For example, it is not a case of « force majeure » when a motor vehicle crashes through the gates and comes into collision with a train, because such an event is far from being exceptional. As far as the responsibility due to the risk of motoring is concerned, the grounds for excluding responsibility due to an « unavoidable happening » allow of much less strict conditions.

On the other hand, the personal error of the individual who is killed, injured or whose property is damaged or that of the individual in control of the damaged property, is of considerable importance. According to the text of the law upon responsibility, *all* personal error exonerates the railway from responsibility. In the mind of the legislator, this clause should form a counterpoise to the very extensive responsibility due to the risk (4). Tribunals have given judgment in this sense. However, since the B. G. B. (civil code) came into force, unvaryingly the tribunals are applying its clause 254 (5) and dividing up the damages according to their estimate of the reciprocal share of the causality of the risk and the individual error.

A logical interpretation of the principle contained in clause 254 of the B. G. B. would mean that the railway always has to share in the damages awarded, no matter how great the error of the injured party, since the risk inherent in operating is always a contributory cause of the accident. But for some time, it has not been the practice to go as far as this. On the contrary, in numerous judgments pronounced in recent years in connection with accidents at level crossings, the railway has been exonerated from all responsibility, because the risk inherent in operating a railway has been completely wiped out in view of the error committed by the road user (6). On the other hand, it is remarkable that a judgment of the Celle Court of appeal dated the 10th December 1953 still estimated the risk inherent in operating a railway as one sixth in the case of an accident when a *closed* gate was crashed through.

III

Jurisprudence has obtained a new aggravation of responsibility by the introduction of the idea of « increased operating risk ». The Supreme Court of the Reich (Reichsgericht) (7) has defined this as follows: « It is the particular form of the risk inherent in the operating which must naturally constitute the basis of appreciation. If circumstances intervene which are not connected in a general and regular way with the operating of a railway, such as local conditions which clearly make the operating of the railway particularly dangerous, for example level crossings without keepers or curves and road crossings in the case of tramways, as well as momentary difficulties, for example shortage of staff or excessive wear of the stock during war years, it can be said that the risk inherent in the operating of a railway is increased or reinforced. » This moreover is not yet the end, for it can be claimed that bad weather increases the risk of operating a *railway* ([8]). A systematic study of all the questions which involve an increased operating risk would be outside the scope of this article ([9]). Jurisprudence has put it into general use. It is to be hoped that a reform of the law regarding responsibility will eliminate this extension to the general operating risk laid down in the laws on responsibility. The essence of the foundations of these laws are being modified inadmissibly « when a notion is introduced which not only generally divides up and increases the risk inherent in operating which is already taken into account in establishing the principe of the responsibility for such a risk, on account of the second, the rule, and the first, the exception » ([10]). The exactitude of these statements is illustrated by a judgment ([11]) which found an increased risk in *railway* operating in the fact that the *driver of a truck had his vision impaired* by the hood of the vehicle when seating on his seat that was tilted backwards.

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(4) Dickertmann in « Die Bundesbahn », 1952, No. 7.

(5) Clause 254 of BGB: « If an error of the victim contributed to the original damage, the obligation to make compensation, as well as the amount of compensation to be paid, depends upon the circumstances, and in particular on the extent to which the damage was due above all to one or other party. »

(6) Furth Court of first instance, 13th May 1954; Court of Appeal Breme, 20th November 1953, VRS 6, p. 119; Court of Appeal Hamburg, 5th February 1954, VRS 7, p. 163; Court of Appeal Carlsruhe, 18th May 1954, VRS 7, p. 173; Court of Appeal Oldenburg, 1st April 1953, NJW 53, p. 1514.

(7) Judgment of 8th December 1919, JW 1920, p. 434.

In the case of accidents at level crossings, the absence of gates, even in cases where it is recognised that such an installation is no longer essential is taken as increasing the operating risk.

On several occasions ([12]), it has been judged that the absence of gates increased the risk inherent in the operating, even when their suppression had been approved by the higher authorities, or again ([13]) that the absence of a warning installation at a level crossing was in principle an increased danger for the road user even if, in virtue of clause 18 of the Operating Regulations such an installation was unnecessary.

On the other hand, in recent years a series of decisions ([14]) have been taken stating : « When a level crossing is legally without gates or warning installation, there is simply the risk inherent in the operating. » With praiseworthy clarity the Court of first instance of Nuremberg-Furth ([15]) states : the absence of gates does not lead to an increase in the risk inherent in the railway. Level crossings with and without gates have the same standing as elements in the operating of a railway. Their presence is sufficiently covered by clause 18 of the Operating Regulations (B. O.). It is not admissible to go further than this prescription and impose a greater responsibility for « increased risk » when there is absolutely no legal obligation to assure additional protection. Such judgments are not in line with the legal position, let alone equitable.

If the risk inherent in operating a railway is itself the cause of an accident, it matters very little whether the risk inherent in operating is normal or increased; the railway has to make full compensation for the damage. But if on the contrary, the road user is at fault and if when the matter is taken to court, an increased operating risk is going to be taken into account as well as the risk inherent in railway operating, then the claim against the railway will be increased. The railway, for example, may have to pay three-quarters of the damages, whereas in the case of normal risk when the road user is at fault, only one

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([8]) Bamberg Court of first instance, 25th February 1954.

([9]) DICKERTMANN (cf. note 4) gives a brief but very complete report with many quotations.

([10]) FRIESE : Reichshaftpflichtgesetz (The law on responsibility), pp. 112 and seq.

([11]) Supreme Court of the Reich, 15th November 1930.

([12]) Brunswick Court of Appeal, 18th February 1954, VRS 7, p. 255; likewise BGH (Federal Court of Justice), 29th September 1952, VRS 5, pp. 38 and seq.

([13]) Bamberg Court of first instance, 25th February 1954.

([14]) Carlsruhe Court of Appeal, 18th May 1954, VRS 7, p. 13; Breme Court of Appeal, 20th November 1953, VRS 6, p. 119; Oldenburg Court of Appeal, 1st April 1953, NJW 53, p. 1514.

([15]) Judgment of the 13th May 1954.

quarter of the damages might have been awarded against it.

Nevertheless — as in the case of normal risk, although under more stringent conditions — the responsibility of the railway can, even in the case of increased risk, be wiped out. The above mentioned judgment of the Nuremberg-Furth Tribunal for example stated in this connection : « The motorist who without paying attention to the level crossing signals and though he has seen a train coming, drives onto the crossing without reducing his speed, which is already too high, commits a *grave* fault as a result of which the risk inherent in railway operating, even though *increased,* is *completely* effaced. » The Hambourg Court of Appeal (16) upheld this opinion that the grave negligence of a motorist habitually excludes the responsibility of the railway on account of the increased risk.

Moreover, it will not be easily understood why it needs at least a *grave* error (to which must be added, in the case of a motorist, the risk inherent in running his vehicle) to exclude the responsibility of the railway when there is increased operating risk, when it is remembered that the responsibility because of the risk is based on considerations of equity.

In this connection, the judgments of American tribunals (17) are of interest because of the obligation they impose on the road user to pay attention. For example, in a lawsuit of the « Baltimore & Ohio Railway Company » against Goodman, it was stated : « When a person goes onto the track of a railway, they must know they are in place where they will be killed if a train comes along before they have crossed the track. They know that it is up to them to stop to let the train pass, as the train will not stop for them. It seems obvious to us therefore that the driver of a vehicle if he is not certain whether or not a train is approaching, should stop his vehicle and get out to make sure. In many, cases, he only need stop and have a look. It seems to us that he is acting entirely at his own risk and peril when hearing neither a train nor any signal, he does not take any other measures of precaution. » In the same way, in a case brought by the « Chicago Milwaukee & St. Paul Railway Company » against Bennet, we can read : « A railway is of its very nature a warning signal of constant danger. »

IV

The above paragraphs have dealt with operating accidents in the sense of the laws on the responsibility of the railway, in the case of which the railway is responsible for damages without having committed any fault. But if there is *also* a fault of the railway, there is *simultaneously* liability to damages both on account of the laws on responsibility and according to the clauses of the Civil Code (B. G. B.) on « illicit actions ». Naturally, the railway may have caused an accident causing damage without this being an operating accident. The distinction is of importance because the responsibility in cases of error assures greater damages — for example as regards pretium doloris — than the responsibility due to the risk. It goes without saying that the simultaneous presence of claims for damage due to the two forms of responsibility does not imply *double damages.*

The railway commits a tort through the action of its employees whose actions are considered to be *its own;* in legal language, they are called its « organs ». A case of a tort committed through the intermediary of organs of the railway is laxity in selecting and supervising employees responsible for such and such a job. This is why the railway is responsible for the errors (which for example through lack of judgment need not be an actual fault) of the so called executives (crossing keepers, drivers, etc.) if it cannot prove that it is not to blame, i.e. if it cannot prove that they have been well selected and supervised; if the executives commit a fault, the railway also is responsible.

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(16) Judgment of the 5th February 1954, VRS 7, p. 163.

(17) Quoted in the article « On the jurisprudence relative to the responsibility of railway undertakings » by SALVISBERG ; « Zeitschrift des Bernischen Juristenvereins », 1930-1931, pp. 62 and seq.

We stated above that an accident due to the condition of the level crossing is not an operating accident. Responsibility owing to the risk does not therefore apply. But the railway is responsible if the crossing is defective through its fault. As regards the conditions necessary for this purpose, it has been stated (18): When crossing a level crossing, the motorist must expect that even if the road was perfectly smooth, that part of the road which crosses over the railway will not be perfectly smooth. If he does not take this into account, the railway will not be responsible.

As a collision with a closed gate is not an operating accident, the responsibility of the railway is not concerned according to the terms of the laws on responsibility; nevertheless the railway is responsible when the accident can be attributed to an error on its part, for example because the gates were not lit up at night. In allocating the damages, the error of the motorist (and the risk inherent in running motor vehicle) and the error of the railway must be weighed against each other. If the motorist runs into the gates whilst they are being closed, the responsibility of the railway is not only that resulting from the laws on responsibility, but also that, much more wide, due to the Civil Code, if they are partly responsible for the accident, for example because the bell was out of order.

In the case of collisions between road users and a train in motion, the cases — which are moreover less frequent — which are juridically the most simple are those in which there is no question of the arrangement of the crossing. If, for example, the railway administration authorises a higher speed on a secondary line than the maximum speed laid down in the Operating Regulations this will be an error which will be held against it in case of accident. In the same way, the railway is responsible when the speed limits are exceeded through the negligence of the *driver* (19) not only on account of the laws on responsibility, but also on account of the error committed unless it can disprove this. In the same way, the railway is generally at fault through its organs when a crossing keeper is unfit for his duties (20) because they should not have employed him.

V

Questions concerning the protection of level crossings are of particular importance. The multiplicity of judicial decisions concerning them shows the difficulties they present from the legal and practical points of view.

It should be noted first of all that infractions of organisations charged with building the roads accordingly to the clauses of the Highway Code (St VO) which makes them responsible for setting up the road signs cannot be invoked against the railway. This seems self-evident, but still does not appear to be undisputed, otherwise it would not be necessary to decide that the absence of warning signs intended to mark a level crossing without gates, in conformity with clause 3 of the Highway Code, appendix 1, fig. 6, cannot be blamed on the railway (21) or that a defect in the equipment repeating the signals at a level crossing is to be blamed on the organisation responsible for making the road (22).

The obligations of the railway as regards protecting level crossings are given in a very complete fashion in the Operating Regulations. In principle, the railway is not obliged to provide protective measures, both from the point of view of the track and that of the operating in excess of the provisions of these Regulations. The protection of level crossings is regulated by the regulations contained in Clause 18 of the Operating Regulations; the question of supervision, as laid down in Clause 46, is less often the subject of litigation. If there is any infraction of this latter provision, the railway is at fault. This is the case, for example, when a level crossing on a main line is not protected in accordance with Clause 18 (3), § 1, by gates or light signals, and no exception to the regulations has been authorised. The railway is liable for damages when this leads to an accident.

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(18) Nuremberg-Furth Court of first instance, 28th January 1954.

(19) BGH, 16th May 1954, VRS 7, p. 54.

(20) Mayence Court of first instance, 23rd December 1953.

(21) Bamberg Court of first instance, 25th February 1954.

(22) Nuremberg Court of first instance, 13th May 1954.

But when a level crossing is protected in conformity with the instructions given when the plans are examined by the competent administrative authorities, within the framework of the Operating Regulations, or according to the prescriptions of the authority in control according to Clause 18 of the BO, verification of these decisions at a later date is excluded. However, most of the tribunals consider such ulterior control admissible and in spite of the decision of the competent administrative authority consider that a fault has been committed when in their opinion the railway should have provided additional protection.

The tribunals base this decision on the obligation to assure the safety of the traffic. They start from the idea that whosoever creates a source of danger must also take all the steps necessary to counteract the dangers which thereby menace a third party. The railway has an obligation to assure the safety of the traffic at level crossings according to the Supreme Court of the Reich (Reichsgericht) (23) and it is on these lines that the great majority of the tribunals, even the Federal Court of Justice (B. G. H.) (24) have decided and are continuing to decide. They also claim that they are competent to check whether, with the existing protection at a level crossing, the railway has met all its obligations concerning the protection of the traffic, even if this protection has been approved by the competent administrative authority. The judgments do not say, no doubt, that contrary to the regulations of Clause 18 of BO, on a secondary line, a level crossing where there is little traffic, or a level crossing with a lot of traffic where the visibility is good, must be protected by gates or light signals, seeing that railway vehicles run over it at a speed of not more than 15 km (9 miles)/h. But they make the point that, for example there is a lot of traffic at the level crossing, or the visibility is poor, and consequently, in spite of the decision of the administrative authority, it should have been equipped with gates or light signals. On this point the Supreme Court of the Reich (25), for example, has clearly stated : the safety installations must conform with Clause 18 of the Operating Regulations (BO); but the tribunal can check if there is a lot of traffic at the level crossing. In a later decision, this Court (26) considered that the tribunals had the right to judge the measures taken by the competent administrative authorities in virtue of Clauses 18 and 46 of BO, and to check if protective measures were suitable, or which measures should be taken at a level crossing (27). The Federal Court of Justice (B. G. H.) (24) has pronounced in detail on all these points, including the question of the *obligation* of the railway to abide by the decision of the higher authority : the railway is responsible for seeing that, according to the type of installation, level crossings are adapted to the exigencies of the existing traffic and sufficiently protected. If, for this purpose, it is necessary to make modifications in the installation, these can only be carried out with the approval of the higher controlling authority, which does not however exonerate the Deutsche Bundesbahn from the obligation to introduce the applicable protective measures immediately without modifying the installation. In addition, the railway must suggest a modification and ask for it to be approved.

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(23) For example, the 19th January 1940, RGZ 162, p. 367.

(24) For example, dated the 21st November 1953, BGHZ 11, p. 175.

(25) Judgment of the 26th August 1935, VAE 36, p. 41.

(26) The 8th March 1937, VAE 37, p. 239.

(27) Likewise, amongst others KG of 13th March 1936, VAE 36, p. 334; Hamm Court of Appeal, 11th June 1937, VAE 36, p. 504; Dusseldorf Court of Appeal, 27th July 1937, VAE, p. 64.

This conception goes too far in affirming peremptorily that the decisions of the administrative authorities are subject to control. The problem cannot be dealt with thoroughly here. In any case, it appears that these powers should only cover the right to control if, since the date when the decision of the administrative authority was given, the position at the level crossing has undergone a *fundamental modification*. The Court of first instance of Breslau once made such a decision (23) in declaring that the decision made by the competent administrative authority when examining the plans, as far as the uselessness of gates is concerned, cannot be controlled by legal means, but that the railway should take into account a *possible increase in the traffic* since the plans were examined and proceed to erect gates. In the decree quoted above of the B. G. H. (24), the general principle that the railway must constantly take steps to adapt their protective measures to the traffic is limited by the following definition: There may be an infraction of the obligation to protect the traffic at a level crossing without gates even when the higher authority has approved the installation of the crossing and has not required any modification to the installation and additional protection *before the accident, which happened many years later*.

Apart from the possibly penal consequences, the question is important from the point of view of the law relating to responsibility, not only on account of the fact that should any fault be committed the damages may be more extensive, but also because of the allocation of responsibility between the railway and the road user regarding the cause of the accident. Just as the increased operating risks increase the damages allocated against the operating undertaking, the error entails, according to Clause 254 of the B. G. B. more serious consequences than the risks inherent in operating.

VI

In most accidents at level crossings, the railway itself *also* suffers damage, which in fact may be considerably greater than the damage suffered by the road user; it is no doubt rare for the railway *alone* to suffer any damage. If it is not a question of a road vehicle, the road user is only responsible in case of error, and then must bear all the damages if the risk inherent in operating does not come into the case as far as the railway is concerned. Consequently, if a horse drawn vehicle erroneously damages a closed or open level crossing gate (29), the driver of the vehicle must compensate the railway. If the driver hits the gate with his vehicle whilst it is being moved, or if his vehicle comes into collision with a train, in which case there is both operating risk and error, the damages are divided up as we have already said, according to Clause 254 of B. G. B. The driver of the vehicle according to this allocation of the blame must compensate the railway to the same extent that he has to pay for *his own* damage; if he was at fault to such an extent that the risk inherent in operating is wiped out in comparison, he must pay compensation for the whole of the damage suffered by the railway. If some fault can also be attributed to the railway, the damages payable by the driver of the vehicle are less than if the railway was merely responsible for the risk inherent in operation.

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(28) The 3rd August 1937, VAE 37, p. 461.

(29) It is not possible to discuss here questions which may possibly arise concerning the responsibility of owners of livestock, nor the responsibility of the owner of the vehicle for his driver (agent executing his orders).

In the case of the owner of a motor vehicle, on the contrary, account has to be taken not only of the error committed, but also of the risk inherent in running a motor vehicle. The owner of the motor vehicle — just like the railway undertaking — has to pay compensation when someone is killed or injured, or property damaged on account of the running of a motor vehicle (Clause 7 of the Highway Code). This responsibility of the owner of a motor vehicle differs in principle from that of the railway in that it only needs an « inevitable happening » which could not be prevented by the greatest care on the part of the owner and driver to exclude the responsibility of the owner of the motor vehicle. In principle, all that we said regarding the responsibility of the railway applies in the inverse sense to the responsibility of the owner of a motor vehicle. In its practical application, the responsibility of the owner of a motor vehicle differs from that of the operator of a railway undertaking on account of the fact that in general the risk due to a motor vehicle is estimated at a lower figure than that due to a railway.

If an accident at a level crossing is due solely to the risk inherent in running a motor vehicle, the owner of the latter is solely responsible for all the damage. This is the case, for example, when stationary gates are damaged entirely on account of the movement of the motor vehicle. The fault of the motorist has no influence except from the point of view of more extensive damages in comformity with the B. G. B. in the case of personal damage. If some fault can be imputed to the railway, without the risk inherent in operating coming into the case (case of an unlit closed gate), then, in virtue of an express regulation of the Highway Code, the damage is allocated according to Clause 254 of B. G. B., just as we reported in the opposite case of the responsibility of the railway (risk inherent in railway operating — victim at fault).

When there is a collision between a railway train and a motor vehicle, there are two operating risks simultaneously; one party may also be at fault, or both of them. According to Clause 17 of the Highway Code, which is based on Clause 254 of B. G. B., the obligation to make compensation, as well as the amount of such compensation, depends in this case upon the circumstances, and in particular on the fact that the damage was caused to a great extent by one or other of the parties. Here the operating risk, which may also be increased in the case of the motor vehicle, must be weighed up, and if necessary the error made by one of the parties weighed against this operating risk, as well as the possible error of the other party. According to the result, *one* or *other* party must pay damages for the whole of the damage suffered by both of them, or each of them must bear the cost of a greater or smaller proportion of their own damage and that of the other party, equally divided up. It may be said in principle that the increased risk counts more than the normal risk and that the fault counts more than the risk inherent in operating. But it is not possible to establish any mathematical formula to estimate the damages; the obligation to pay compensation depends in fact, as the law states, upon the actual circumstances. The natural result is that there will also be some doubts from the real point of view; this is why accidents at level crossings so often result in lawsuits. All we can do is to refer to the judgments already quoted, according to which the gross negligence of the motorist excludes in general the responsibility of the railway, even in the case of increased risk. In cases of this kind, the owner of the motor vehicle must *in normal cases* compensate the railway for the damage caused to it.

Clause 7 of the Highway Code (St VG) also applies, when a gate is run into, as far as the injuries suffered by a third party or a passenger on the train are concerned who is hit by a gate thrown over by the train; it does not apply to an injured occupant of a motor vehicle (by reason of Clause 8 II of the Highway Code) except a fare paying passenger on a public transport vehicle or when the owner of the motor vehicle is at fault.

Clause 17 of the Highway Code raises a whole series of problems, for example as regards the blame to be allocated to the *driver* of the vehicle when the *owner* is not to blame, the rights of those travelling in the motor vehicle in the case of free or private transport, the application to slow vehicles which from the point of view of responsibility do not come under Clause 7 of the Highway Code. These problems cannot be dealt with in a few words: to study them would mean considerably exceeding the limits we have been set. It will be sufficient therefore to mention the principles.

VII

The accountable regulation of claims has been practiced in various ways. The Supreme Court of the Reich was of the opinion that there should be a general writing off. Difficulties would result, especially when it was impossible to foresee the final amount of the damage. The Federal Court of Justice (Bundesgerichtshof) (30) has now made the following rule: if the railway and a motor vehicle are in dispute on account of an accident and if the undertaking and the owner are responsible for the damage caused, their rights to settlement of the compensation are independent of each other. The conception of the Supreme Court of the Reich is to be rejected according to which it is necessary first of all to calculate the total amount of the damage and only then to determine which of the parties concerned shall compensate the other for the difference, as there is no law that compensation should be regularised solely by a general claim covering the whole of the damage.

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(30) The 27th October 1954, « Betriebsberater », 1955, No. 2, p. 49.

[625 .14 (01]

Resistance to warping of continuously welded old and new rails,

by Dipl.-Ing. Helmut Rubin, Mainz.

(*Eisenbahntechnische Rundschau,* No. 9, September 1955.)

In view of the satisfactory experience with continuously welded rails of Reichsbahn K type and concrete sleeper type permanent way, the question has been put repeatedly whether it would not also be possible to weld, to a much greater extent than now, the tracks of the older types of permanent way which have less rigidity. On the other hand, misgivings have been expressed from time to time as regards the resistance to warping of continuously welded rails, at present still new, after a long period of wear on rails and rail fastenings. Closely related with both problems is the question whether very heavy rails (S 64, S 55), which exert correspondingly greater pressure, can be safely subjected to continuous welding even with lighter types of fastenings (H type permanent way with screws or elastic spikes).

It is of interest to examine these questions with the aid of the methods, published by various experts, for the calculation of track stability. The following calculation results, shown in tables and diagrams, are based on a simplified method, developed by H. Meier, for the theoretical examination of track warping (*Organ für die Fortschritte des Eisenbahnwesens*, 1937, No. 20). This is an approximation method based on the energy principle. On the assumption of an elastic line approximated to that of the actual deformation of the track, the energy values required to produce a failure are compared with those set free at the time of the disturbance due to the existing compressive forces. Buckling takes place when a critical deformation value f has been exceeded. The value of f is composed of local track laying errors and by displacements caused by traffic. According to measurements taken and practical experience, a vertical and horizontal deviation of $f = 5$ cm in curves and a horizontal error of $f = 2.5$ cm on straight track can be assumed in unfavourable cases.

The maximum track pressures at which the resistance to warping of continuously welded track is still ensured determine the lowest temperatures (SW in °C) at which it is permissible to fasten the tensionless continuously welded rails to the sleepers. If the track is laid at a lower temperature, there is a danger that the continuously welded track will buckle at high temperatures. SW° can be calculated from the following formulas which have been derived, by transformation, from the equations given by H. Meier :

(1) Vertical warping on straight track :

$$SW^{o}_{zul} = 60^{o} - \frac{\sqrt{\frac{g}{f}\,16\,E\,J} - C}{2\,\alpha\,E\,F}$$

(2) Vertical warping on straight track at a convex change of gradient :

$$SW^{o}_{zul} = 60^{o} - \frac{\sqrt{\frac{g}{f}\,16\,E\,J + \frac{64\,E^2\,J^2}{H^2 f^2}} - \frac{8\,E\,J}{H f} - C}{2\,\alpha\,E\,F}$$

(3) Horizontal warping on straight track :

$$SW^{o}_{zul} = 60^{o} - \frac{\sqrt{\frac{w}{f}\,8.7\,E\,J} - C}{2\,\alpha\,E\,F}$$

(4) Horizontal warping in curved track :

$$SW^0_{zul} = 60^0 - \frac{\sqrt{\frac{w}{f}\,16\,EJ + \frac{64\,E^2\,J^2}{R^2 f^2}} - \frac{8\,EJ}{Rf} - C}{2\,\alpha\,E\,F}$$

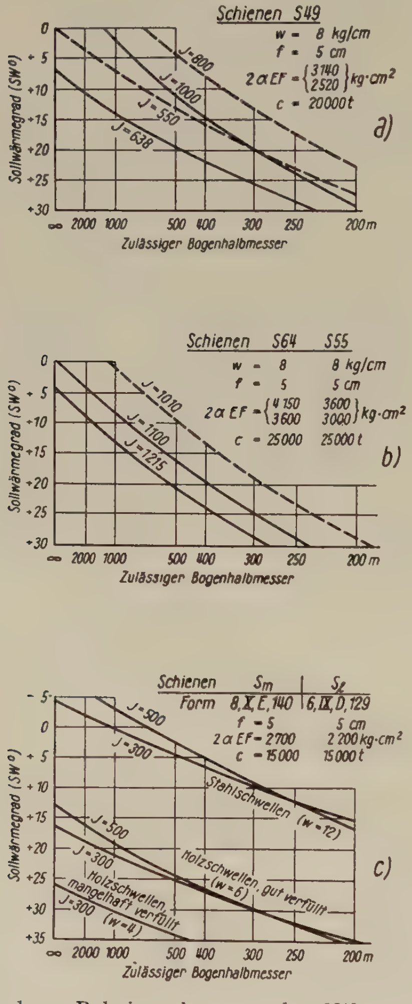


Fig. 1. — Relations between the SW temperatures of continuously welded track and permissible curve radii.

N. B. : Sollwärmegrad = SW temperature (at which the tensionless welded rails are fastened to the sleepers). — Zulässiger Bogenhalbmesser = permissible curve radius. — Schienen = rails. — Stahlschwellen = steel sleepers. — Holzschwellen, gut verfüllt = wooden sleepers with good ballast packing. — Holzschwellen manglehaft verfüllt = wooden sleepers with deficient ballast packing.

Herein are :

f = deformation in cm;

g = weight of track in kg/cm;

w = transverse resistance of track against lateral displacement, in kg/cm;

E = modulus of elasticity of the rails in kg/cm² of track length;

J = moment of inertia of the rails (= 2 J_x or 2 J_y) or the equivalent moment of inertia of the track frame, in cm⁴;

H = radius of vertical curve at a change of gradient, in cm;

R = curve radius, in cm;

α = heat expansion coefficient of the rails (0.000012);

F = cross-sectional area of both rails, in cm²;

C = force equivalent, in kg, of the temperature tolerance during track laying operation, taking into account local force concentrations, etc. (C = 15 000 to 25 000 kg).

60° = maximum rail temperature during the summer.

The results of the calculations are shown in Tables 1 and 2 and figures 1 and 2.

Some of the values were checked by means of the method indicated by A. MARTINET (« Flambement des voies sans joints sur ballast et rails de grande lon-

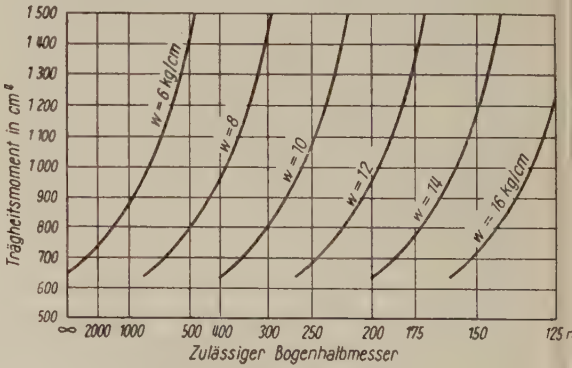


Fig. 2. — Relations between the moment of inertia of continuously welded track with new S 49 rails, their transverse resistance w, and the permissible curve radii at a temperature difference of 45 °C.

N.B. — Trägheitsmoment = moment of inertia — Zulässiger Bogenhalbmesser = permissible curve radius.

TABLE I. — **Lowest permissible temperatures (SW) which must be observed in order to avoid the danger that continuously welded straight track, laid at that temperature, will buckle in the** *vertical* **direction at higher temperatures. Critical deviation** $f = 5$ cm.

Rails		Sleepers	Weight of track kg/cm	Moment of inertia cm^4	Admissible track pressure tonnes	SW temperature °C
S 49	new	concrete	4.5	3 590	330	—38°
S 49		wood	3	3 590	268	—18° (—21°)
S 49		steel	2.4	3 590	235	—10°
S 49	old	wood	2.7	2 700	221	—20°
S 64	new	wood	3	6 500	362	—21° (—22°)
S 64	old	wood	2.8	5 000	306	—17°
S 55	new	wood	2.8	5 120	310	—19°
S_m		steel	1.9	2 800	189	—4°
S_l		steel	1.7	2 000	151	—2°

( ) Figures in brackets are calculated by means of MARTINET's method.

TABLE II. — **Lowest permissible temperatures (SW) which must be observed in order to avoid the danger that continuously welded straight track, laid at that temperature, will buckle in the** *horizontal* **direction at higher temperatures. Critical deviation** $f = 2.5$ cm.

Rails		Sleepers	Transverse resistance kg/cm	Moment of inertia cm^4	Admissible track pressure tonnes	SW temperature °C
S 49	new	wood	8	638	193	+5° (+5°)
S 49		wood	8	1 000	242	—10° (—10°)
S 49	old	wood	8	550	179	—30°
S 49		wood	8	800	216	—18°
S 64	new	wood	8	1 215	266	+2°
S 64	old	wood	8	1 100	254	—4°
S 55	new	wood	8	1 100	254	—4°
S 55	old	wood	8	1 010	243	—13°
S_m	new	wood	6	500	148	+11°
S_m		steel	12	500	209	—12°
S_l		wood	4	300	94	+24°
S_l		wood	6	300	114	+15°
S_l		steel	12	300	162	—7°

( ) Figures in brackets are calculated by means of MARTINET's method.

gueur », *Revue Générale*, 1936, No. 10). The agreement was excellent. MARTINET examined the elastic lines of the track for the critical equilibrium conditions.

Table I shows that the tracks are completely safe against vertical warping since SW temperatures below 0 °C do not occur in practice. The influence of the weight of the track, apparent from the values for S 49 rails on concrete, wooden and steel sleepers, is considerable, though it is generally without practical significance.

Conditions with old rails whose cross-section is already reduced are no worse than with new rails.

With rails of the medium-heavy and light types (S_m = approx. 43 kg/m and S_l = approx. 34 kg/m of rail), some caution is required, especially with steel sleepers, at convex changes of gradient with comparatively small vertical curve radius. If necessary, heavier sleepers would have to be used here. In such cases, e.g. with a vertical curve radius of 2 000 m, the minimum SW temperatures are increased by about 15 °C.

Table II and figure 1 show the conditions governing the resistance to warping in the horizontal direction. In this connection, it must be noted that the moment of inertia of track is influenced by the quality of the rail fastening. If the fittings are very loose, it is only permissible to reckon with the moment of inertia of the two rails individually. But if the fastenings are tight and force-locked, the points of contact between rails and sleepers are able to transmit friction forces. In this case, the frame formed by the track is equivalent to a frame girder of a certain rigidity, with a correspondingly greater moment of inertia. For instance, two new S 49 type rails have a moment of inertia of $J = 2\ J_y = 638\ \text{cm}^4$ when the screws are loose but, according to measurements, one of at least $J = 1\,000\ \text{cm}^4$ when they are tight. With heavily worn S 49 type rails (indicated by a broken line in fig. 1 *a*), where the cross-sectional area is reduced by about 25 cm^2 corresponding to the final conditions of rails admitted for use in track of Group 2 (Az Obv 27), the corresponding moments of inertia are $J = 2\ J_y = 550\ \text{cm}^4$ and $J = 800\ \text{cm}^4$. With rails of types S 64, S 55, S_m and S_l, the calculation has always been based on the moments of inertia of the two rails individually because these rails are laid with screws or spikes of H type permanent way, or with fittings of the older types of permanent way of the former State railways, which are little suited to transmit stresses.

Part *a*) of fig. 1 shows that the new S 49 type rail, used as part of H type permanent way (J = 638), can safely be subjected to continuous welding at temperatures not lower than + 15 °C, even in curved track having a radius of not less than 1 000 m. With the rigid rail fastenings of K type or concrete sleeper type permanent way (J = 1 000), the continuously welded rail has an adequate resistance to warping, with SW° = + 15 °C, even in curves of 400 m radius. With an SW° temperature of + 20 °C, these rails would even be safe in curves of 300 m radius.

In all cases, conditions become more favourable with increasing rail wear (broken lines). This also applies to all other forms of rails.

According to fig. 1 *b*, continuously welded new rails of type S 64 remain, because of their great moment of inertia (J = 1 215), safe against warping in curves of 500 m minimum radius when laid at temperatures not lower than SW° = + 20 °C, in spite of the greater axial forces due to the larger cross-sectional area. A new rail of type S 55 which corresponds to a worn rail of type S 64 (J = 1 100), would buckle at a radius of less than 400 m. But a worn rail of type S 55 (J = 1 010) would only be endangered in curves with less than 300 m radius.

With rails of the medium-heavy and light types, resistance to warping is decisively influenced by the transverse resistance of the track which, in turn, depends on the type of sleepering and the cross-section of the ballast. When laid on steel sleepers which give the track a good resistance against lateral displacements, these rails can generally be subjected to continuous welding without any misgivings. On wooden sleepers, however, these rails, especially on open sections of line outside the stations, may only be subjected to continuous welding if a high degree of ballast packing is ensured ($w = 6$, ballast cross-section according to « Az Obv 6 »), and if curves with radii below 500 m are excepted. For, because of the axial tensile forces encountered during the winter, it is not advisable to lay such rails at temperatures below $SW = + 25\ {}^{o}C$. To what extent it may be possible to make exceptions for station sidings which are under continual observation will depend on local conditions.

Figure 2 shows the influence of the transverse resistance and of the moment of inertia on the resistance to warping of continuously welded track in curves.

The general results of these investigations can be summed up as follows :

1. Because of their particularly great moment of inertia, heavy rails can be continuously welded even when laid with simple, non-rigid fastenings.

2. With medium-heavy and light types of rails, the type of sleepering and the ballast cross-section have an important bearing on the resistance to warping. In such cases, it is advisable to examine, before the welding takes place, the safety against warping in accordance with local conditions, and to determine the minimum temperature at which the rails may be laid.

3. Because of the rail wear, the safety against warping increases to some extent with the age of the continuously welded track. It is therefore possible to accept a certain amount of slackness in the rail fastenings and a consequent reduction in the frame rigidity of the track. It must however be noted that, with very old track, the safety against warping is jeopardized if, because of gauge amplification, vehicles vibrating in the transverse direction of the track generate important lateral impact forces, of if the rail fastenings, perhaps because of deterioration of the sleepers, are no longer able effectively to transmit the horizontal and vertical forces to the sleepers.

[625 .285]

The technical evolution of the fast automotor trains and the results obtained in service.

Exploiting the experience acquired to design the future trains « Trans-Europ-Express »,

by Dipl.-Ing. Otto Taschinger.

(*Die Bundesbahn*, No. 6, March 1956.)

With the introduction of the summer 1933 timetables, the former German Reichsbahn put into service on the Berlin-Hamburg line the fast Diesel automotor trains known as the « Fliegender Hamburger » (Flying Hamburger). Whereas till then the long distance trains in general service did not run at more than 100 km (62 miles)/h, these fast automotor trains ran for the first time at a normal speed of 150 km (93 miles)/h, which could be increased to 160 km (100 miles)/h if there was any delay. Owing to their high average speed, 125 km (77 miles)/h, these fast trains were greatly liked by the public from the time they were put into service. Their financial returns were therefore assured right from the start; all the costs, including sinking fund, interest, improvement of the installations, etc., were more than covered. It soon became necessary to put fast automotor trains into service on other through runs. The experience obtained as regards both operating and maintenance was fully made use of in designing the later rakes. Hence the apparition between 1933 and 1954, naturally with an interruption for the war years, of a series of types of fast Diesel rakes, with various differences both from the point of view of their engines and in the actual construction of the vehicle, which give a very clear picture of the tendencies in the constructional evolution of fast railcar rakes on the Reichsbahn, subsequently on the Bundesbahn, if the leading dimensions of these units, as shown in Table I, are compared.

Running gear.

At the beginning, first of all double and triple railcar rakes were built (« Hambourg » and « Leipzig » types), which had motor bogies at the ends of the rake and Jakob bogies between the units. In the triple and multiple types which followed (Cologne and Berlin types long distance series 08 rake), both the end units (motor unit, unit with the driving cab) and the middle units consisted of four-axled vehicles each with two bogies, the different units being rigidly coupled. The two articulated rakes represented to some extent the end of the evolution of fast railcar units. The articulated sleeping car rake, with 8 sleeper-units, had Jakob bogies between the rigidly-coupled units, whereas on the 7 unit day-service articulated rake, there were two wheeled trucks controlled by the different coaches.

The running gear influences the design, weight and cost of construction of a railcar rake. It has a considerable influence upon running stability and on inside noise, especially at high speed. Finally, the type of running gear chosen affects maintenance costs. As all the different types of railcar rakes have run a considerable mileage, in most cases several million km, it is possible to form a final estimate of the suitability of various types of running gear for fast railcar rakes running at more than 120 km (74 miles)/h.

With the « Jakob » type, there is a Jakob bogie under the two ends of adjoin-

TABLE 1. — **Principal dimensions of the fast Diesel railcars.**

	Type of railcar	Year of delivery	Number	Width of the coach		Type of bogies (with exception of end bogies)	Distance between bogie centres	Wheel base of the bogie			Length of the different coaches								Distance between coaches	Total length of the rake
				exterior	interior			Bogie carrying the engine	Motor bogie	Carrying bog.	Motor unit	Intermediate coach						Coach with driving compartment		
												1	2	3	4	5	6			
				mm	mm		m	m	m	m	m	m	m	m	m	m	m	m	m	m
1	SVT 04.1 double « Flying Hamburger »	1933	1	2820	2652	Jakob bogie	16.9	3.5	3.5	—	20.778	—	—	—	—	—	—	—	0.35	41.906
1*a*	SVT 04.5 double, Hamburg type	1935	13	2820	2652	»	18.075	3.5	3.5	—	21.953	—	—	—	—	—	—	—	0.35	44.256
2	Triple. SVT Diesel-electric, Leipzig type	1936	2	2830 Intermediate coach 2858 Coach *a* & *b*	2676 Intermediate coach 2704 Coach *a* & *b*	»	16.875 17.8	4.0	3.5	3.5	20.75	17.45	—	—	—	—	—	—	0.35	59.65
2*a*	The same, Diesel-hydraulic	1936	2	»	»	»	16.875 17.8	4.23	—	3.5	20.75	17.45	—	—	—	—	—	—	0.35	59.65
3	Triple SVT 06. Cologne type electric	1938	14	2859	2706	Separate bogies	16.12 16.135	4.0	3.5	3.0	23.12	21.935	—	—	—	—	—	—	0.665	69.505

TABLE 1. — **Principal dimensions of the fast Diesel railcars.** *(continued)*.

	Type of railcar	Year of delivery	Number	Width of the coach exterior	Width of the coach interior	Type of bogies (with exception of end bogies)	Distance between bogie centres	Wheel base of the bogie: Bogie carrying the engine	Wheel base of the bogie: Motor bogie	Wheel base of the bogie: Carrying bog.	Length of the different coaches: Motor unit	Intermediate coach 1	Intermediate coach 2	Intermediate coach 3	Intermediate coach 4	Intermediate coach 5	Intermediate coach 6	Coach with driving compartment	Distance between coaches	Total length of the rake
				mm	mm		m	m	m	m	m	m	m	m	m	m	m	m	m	m
3a	The same, Diesel-hydraulic	1938	2	2859	2706	Separate bogies	16.12 16.135	4.0	—	3.0	23.12	21.935	—	—	—	—	—	—	0.665	69.505
4	Four-unit SVT. Berlin type	1938	2	2850	2685	»	15.865 16.78	3.0	3.0	3.0	Eng. 17.0	22.58	22.58	—	—	—	—	22.565	0.665	86.755
5	Triple VT 07.5 ex-Berlin	1938	2	2850	2685	»	15.865 16.78	3.6	—	3.0	22.565	22.58	—	—	—	—	—	22.565	0.665	69.04
6	Triple VT 08.5 long distance	1953	14	2814	2694	»	19.0	3.6	—	2.5	26.025	25.76	—	—	—	—	—	26.025	0.72	79.25
7	The same, with 4 coach.	1954	6	2814	2694	»	19.0	3.6	—	2.5	26.275	25.76	25.76	—	—	—	—	—	0.72	105.98
8	The same, with 5 coach.	1954		2814	2694	»	19.0	3.6	—	2.5	26.275	25.76	25.76	25.76	—	—	—	—	0.72	132.46
9	Articulated day-service rake with 7 coaches VT 10 501	1954	1	3024	2884	Two wheeled truck	12.2	2.2	—	—	17.4	11.8	11.8	11.8	11.8	11.8	—	—	0.4	92.2
10	Articulated sleeping-car rake with 8 coaches VT 10 551	1954	1	3024	2884	Jacob bogie	12.2	2.2	—	2.0	17.3	11.6	11.6	11.6	11.6	11.6	11.6	—	0.6	108.4

ing rigidly coupled coaches. There is therefore one demi-bogie for each demi-coach. The end coaches of a multiple rake have in addition to the corresponding demi-bogie, a four wheeled bogie carrying the engine on the motor unit, and a four wheeled carrying bogie on the unit with the driving compartment. In the case of a triple unit, two « Jakob » bogies are needed, in the case of a four unit rake, 3, and in the case of a five unit rake, 4. If n is used to denote the number of intermediate coaches of a multiple rake, such a rake will require $n + 1$ bogies when mounted on « Jakob » bogies. With multiple rakes composed of four axled vehicles with two bogies (bogie type), leaving out the end bogies of the rake, in the case of a triple rake, 4 bogies will be needed, for a four unit rake, 6, and for a five unit rake, 8 bogies (usually carrying bogies). Again using n to denote the number of intermediate units, with a multiple rake of bogie vehicles, there will have to be $2\ (n + 1)$ bogies. With the « Jakob » type, leaving out the end bogies of the rake, it is possible to save half the number of bogies. The more intermediate units there are, the greater the advantage.

The single axled trucks controlled by the bodies of the coaches used on the day time articulated rake are also mounted between the two ends of adjoining coaches. What we have just said about Jakob bogies from the point of view of their influence on the design, weight, constructional cost, running stability, etc., therefore apply in this case also, with the necessary adaptations.

Amongst the most important parts of a coach affected by wear are, as is well known, the axles and axle boxes, the axle-box guides and suspension springs, especially when subjected to heavy stresses. The number of bogies on a railcar rake influences maintenance costs. In the case of railcar rakes fitted with bogies with freely guided axles (« Görlitz » type), the bogies have to be replaced after a mileage of 50 000 km (31 068 miles) owing to the deterioration in running, the running surfaces of the wheels have to be turned and if necessary the play in the axle-box guides corrected. With modern bogies where the axles are guided without play, on the other hand, we get mileages of 100 000 to 150 000 km (62 000 and 93 000 miles) without deterioration in the running quality. The proportion of the total maintenance costs of a coach attributable to the running gear compared with the mileage covered is thus considerably reduced.

On a 4 wheeled « Jakob » bogie is taken the load of two half-bodies, in other words the weight of a whole coach body. On the running gear of an axle of the articulated day service rake, there is also the whole load of an articulated unit. On the other hand, with a four axled two bogie coach, each bogie never has to support more than half the load of a coach; it must not be forgotten however that this coach body is elongated by the two overhanging portions and consequently heavier. As it carries a greater load from the body of a coach, the « Jakob » bogie must be bigger in size. « Jakob » bogies therefore have a heavier bogie frame, and stronger axles, axle boxes and suspension springs. The compressed air brake installation is also made more robust owing to the increased axle loads. The weight and cost of a « Jakob » bogie are therefore considerably higher than those of a four axled coach bogie. For example, the « Jakob » bogie of the Leipzig type fast rake weighs 8.85 t whereas the carrying bogie of the Berlin type fast rake (bogie construction) only weighs 7.35 t, i.e. 1.5 t or 17 % less than the former.

Owing to the higher load carried « Jakob » bogie exert a greater pressure per axle than the four axled coach bogies. For example, the « Jakob » bogies of a Leipzig type fast rake have an axle load of 13.9 t, whereas the carrying bogies of the Berlin type rake only have a load of 11.1 t per axle. A high axle load is only desirable in the case of motor axles where a correspondingly high motor power is available. It is only in the case of the Diesel-electric rakes that the traction motors are fitted on the « Jakob » bogie of the motor unit; on the Diesel-hydraulic rakes the « Jakob » bogie is a carrying bogie. It is known

TABLE 2. — **Proportion (%) of the weight of the carrying bogies in the total weight of the rake.**

Type of railcar	Length of the rake	Length of an intermediate coach	Weight of the rake	Weight of the carrying bogies — Type of running gear: Jacob bogies	Weight of the carrying bogies — Type of running gear: Bogies	Percentage of the weight of the carrying bogies compared with the total weight of the rake
	m	m	t	t	t	%
Leipzig	59.65	17.45	127.66	2 × 8.85	—	14
Cologne	69.5	22	162.72	—	4 × 7.35	18
Séries 08	79.25	25.8	120.45	—	4 × 3.57	12
Articuled sleeping-car rake	108.4	11.6	111.70	7 × 3.0	—	17

that an increased axle load leads to faster wear of the tyres. As the weight per axle increases there is also an increase in the power to be absorbed in braking and turned into heat. In the case of the fast motor rakes, the reduced number of axles due to the use of « Jakob » bogies is therefore generally of no advantage from the braking point of view, especially when the high running speeds are taken into account. On the contrary, it becomes necessary to divide up the braking power between a fairly large number of axles because it is then easier to disperse the heat generated by braking in the tyres.

The percentage of the weight of the carrying bogies to that of the whole rake is given in Table 2. It is true that a comparison of the percentage of weight, if it is not to give rise to criticisms, should be made with rakes of the two different types of construction having an identical number of coaches, identical internal arrangements (comfort), coach bodies and bogies built according to the same principle (light weight construction) and with identical motor equipment. However, the Table gives sufficiently close points of comparison as far as the influence of the carrying bogies on the weight of the rake is concerned. Thus, we are led to conclude from Table 2 that it is advisable to extend to the maximum the space between the bogie pivots and to make the carrying bogies as light as possible. However, increasing the space between pivots means reducing the width of the body; it is therefore limited by the comfort requirements of the fast motor rakes.

With the « Jakob » arrangement, the ends of the coaches that are rigidly connected rest on a common centre-casting and are consequently protected to a great extent against transversal movements. In the case of the coaches with four axled bogies, the transversal movements of the ends of the coach bodies can be damped out by a very tight coupling, in other words by the friction of the buffer heads against each other. With couplings with a centre buffer, there are not usually any such plates. It is known that the horizontal stability of running perpendicularly to the axis of the track especially at high

TABLE 3. — **Proportion of the overhang of the bodies at the intermediate ends with rigid coupling.**

Triple fast railcar Type	Arrangement of running gear	Length of the rake	Total length of the overhang of the bodies at the ends with rigid coupling	Proportion of the overhang of the bodies at the ends to the rigid coupling
		m	m	%
Leipzig	Jakob bogies	59.65	—	0
Cologne	Two bogies under each coach	70.205	11.6	16.5
Berlin		69.04	11.6	16.9
Series 08		79.25	13.52	17.4

speeds, is rather better in the case of the rakes with « Jakob » bogies than in the case of the rakes with ordinary coaches with bogies if these latter are not very tight coupled.

This drawback can be eliminated by fitting supplementary stabilizing devices between the coaches that are connected together by means of a center buffer coupling. We will return to this point when dealing with the running quality achievable with the fast motor rakes.

If in spite of the advantages mentioned above, the « Jakob » bogies have not become the only possible choice for the fast motor rakes, this is on account of the drawbacks they entail.

The bodies of coaches on « Jakob » bogies end in the immediate vicinity of each other above the common pivot. On the other hand, coaches with ordinary bogies have an overhang at each end, in other words the body is extended beyond the two pivots by an amount which is only limited by the outside limits conforming with the arrangement according to Technical Conventions. Coaches fitted with « Jakob » bogies are therefore shorter than those with their own bogies by the amount of this overhang. With a pivot spacing of 12.6 m the overhang is about 2.4 m without it being necessary to reduce the width of the coach. In such a length, however, it is possible to fit in a whole second class compartment with six seats. In the case of the motor rakes with « Jakob » bogies the amount of the overhang must be given up in the case of each of the end vehicles (motor unit or driving compartment trailer) and two overhangs in the case of each of the middle vehicles. This means that with a triple rake at least 24 second class seats are lost, with a four unit rake, 36 seats, and with a five unit rake, 48 seats. With this loss of seats there is a corresponding saving in carrying bogies, a shorter rake and a lighter rake. With a triple rake on « Jakob » bogies there is a saving, compared with a rake of four axled coaches, of 2 carrying bogies, with a rake of four units, 3 and with a rake of five units, 4. Table 3 shows the proportion compared with the length of the rake of the overhangs of the coach bodies at the close-coupled ends for the different types of triple motor rakes.

A study made with the Cologne type express triple motor rake (with ordinary bogies) has shown that in the case of a comparable motor rake on « Jakob » bogies, there is a total loss of 23.5 % of the seats. On the other hand, the adoption of « Jakob » bogies reduces the weight by about 4 %. The weight per seat in the case of a motor rake on « Jakob » bogies is generally higher than that of a comparable motor rake made up of coaches with four axled bogies, under the same conditions of comfort and capacity. For equal capacity, and therefore more or less the same length of rake, the use of « Jakob » bogies on account of the shorter bodies means that a greater number of coaches must be used than when ordinary bogies are used, which involves a greater number of intercommunication installations. Each such installation involves additional expenditure and increased weight on the frame headstocks, the body ends, the doors in these ends, the draw and buffing gear, the compressed air pipes, control pipes, the mobile gangways, the bellows, and the cost of sound insulation.

It is not usually possible to have any platforms with inside steps in line with the « Jakob » bogies, unless such bogies with inside axle boxes are used, or in the case of coaches with particularly low floors, possibly with foot boards which can de raised towards the outside. It is also difficult to fit any toilet compartments in the ends of such coaches. It is usually necessary consequently to have passenger compartments at the ends of the coaches, although the running qualities are poorer and the noises louder here than in the middle of the coach. To overcome such noises, additional constructional measures must be introduced if compartments in such a position are to be sufficiently well insulated from the acoustic point of view. If there should be a collision, the end compartments are much more exposed to the risk of damage.

The servicing and maintenance of rakes on « Jakob » bogie rakes means having shops and depots reached through points, as such rakes cannot use the turntables or transfer conveyors. In the shops, there must be pits available for dropping the bogies, in order to avoid having to lift two coach bodies in order to replace a bogie. If the rake gets derailed, the breakdown gangs must be much more highly skilled than in the case of rakes made up of single coaches which it is possible to uncouple from each other.

The Operating Department complains that with these rakes it is impossible to add extra units or shorten the rakes on the station sidings. This method of construction is therefore only suitable in the case of rakes dealing with a relatively constant traffic. On lines where the train user varies considerably on certain parts of the line, motor rakes made up of coaches on ordinary bogies are preferred, as these rakes can be altered in the stations. The coaches with ordinary bogies are also the best when it is necessary to take a damaged coach out of a train.

Good running.

The good running of the fast motor rakes is a function of the running way, i.e. the track and its state of maintenance, in particular the length of the rails, the joint gaps, as well as vertical and horizontal differences in the layout and the gauge. Stability of running also depends on the method of construction and state of maintenance of the running gear. The axle spacing, the equal diameters of the running circles (wheel treads) of the two wheels of an axle and the balance of the axles, their guiding in the bogie frame, the type of suspension of the axle box and the body, the flexibility of the suspension, the state of the rubbing surfaces of all the sliding parts, the weight of the running gear in proportion to the weight of the body, and finally the method of support of the body of the coach on the bogie frame, condition the running stability. With the increase in running speeds, up to 160 km/h when the fast Diesel rakes were put into service, the problems of the quality of running have become even more important, because with the higher speeds the impetus of shocks on the running gear follow each other faster and the disturbing accelerations are stronger. Not only do the vertical and horizontal vibrations become greater, but the frequencies themselves increase.

In studying the fitting of engines and the motor bogies, another difficulty has arisen, due to the fact that the motive powers have increased in the meanwhile from

410 to 1 000 HP. The space and weight required for the mechanical installations are making it more and more difficult to design motor bogies or bogies on which the motors are fitted. There has often had to be compromises, which necessarily affect smooth running. The axle spacing has often had to be increased up to 4.23 m. Experience has shown that with Diesels a power of 1 000 HP is the limit technically for housing the motor equipment in the bogie. The engine mounted on the bogie is only suspended by the axle springs on the boxes. The heavy mass of the motor bogie gives rise to considerable stressing of the axles, axle boxes and suspension springs. These may have a harmful effect on the quality of the running. The steps to be taken in studying the motor bogies to get sufficiently good running qualities correspond largely to those required in the case of carrying bogies. They can therefore be dealt with when speaking of these bogies.

The most important types of bogies for the fast motor rakes have been grouped in Table 4.

In carrying bogies built before the war, spiral springs and laminated springs were used for the suspension of the axle boxes and the swing bolster; in the types put into service since the war, coiled springs only have been used, which necessarily involves the use of hydraulic shock absorbers for the suspension of the body. In the bogies used before the war, the axle boxes were guided in the slides of the guide plates. The play between the box and the slide influences the sinusoidal running of the bogie. It must therefore be kept as small as possible. But as the slides become more and more worn during running, so that the longitudinal play of the axles is constantly increasing, the running becomes worse and worse. To avoid this drawback, first of all adjustable slides were fitted, but these are not always adjusted during service or the adjustment is not carried out sufficiently carefully. Such types of bogies only run 50 000 km (31 000 miles) between overhauls. Since the war, only bogies fitted with rods to guide the axles, of a great many types, have been used; with these the axles are guided without any longitudinal play. This method of guiding is the most important step forward in improving the quality of the running.

With carrying bogies of the « Görlitz » type, the body of the coach rests on the centre plate of the swing bolster. This method of support means having heavy main longitudinal members for the body frame and heavy swing bolsters; in addition it is not stable. The coach bodies of the series 08 fast motor rakes and those of the articulated rakes rest on the contrary on the two side frames or solebars of the bogie through the intermediary of sliding surfaces or rollers. The main longitudinals of the body frame are less strongly stressed in this way; they can therefore be of considerably lighter construction; the bogie swing bolsters can be suppressed. As a result, for example, the carrying bogies of the Cologne type triple motor rake (« Görlitz » bogie) weighs 6.92 t whereas the carrying bogies of the series 08 triple motor rake only weighs 3.57 t. In addition, this method of support damps out to some extent the movements of the bogie by the friction of the bearing surfaces.

In the series 08 triple Diesel rake, for the first time use was made of bogies with inside boxes with guide sleeves with transversal springs in rubber for the pivots. In addition, for the first time, an additional rubber suspension was used for the body of the coach.

A Kruckenberg type two wheeled truck of the day service articulated rake differs fundamentally from the four wheeled carrying bogies of the usual type. This is guided radially in the track by the body of the coach. The ends of the bodies of two adjoining articulated units rest by means of an elastic strut on the frame of the truck (fig. 1). To get a sufficiently soft suspension of the body, the two coiled springs of the elastic strut had to be made 922 mm long. The two springs have a total of 17 coils. The total height of the elastic strut (fig. 2) is 1 100 mm (coach empty). A spiral spring of this length has to be guided in a telescopic tube. At the bottom, there is an oil shock absorber,

TABLE 4. — **Most important types of bogies.**

Type of railcar	Type of carrying bogie	Wheel-base	Diameter on wheel tread	Weight	Suspension of axle box	Suspension of body	Flexi-bility	Dampers for		Guiding of axle boxes	Swing bolster and body support	Position of the boxes	
		m	mm	kg			cm/ 1 000 kg	Axle-box springs	Body springs			outside	inside
Hamburg type (04.5)	Jakob bogie (Görlitz type)	3.5	1000	7400	Laminated springs and helical springs	Laminated springs	1.078	—	—	Axlebox guides with adjustable wedge	With swing bolster; centre-casting	yes	—
Cologne type (06.1)	Görlitz III bogie	3.0	930	6920	Laminated springs and helical springs	Laminated springs and helical springs	1.224	—	—	Axlebox guides with adjustable wedge	With swing bolster; centre-casting	yes	—
VT 08.5	Munich-Deutz	2.5	900	3575	Helical springs	Helical springs	1.995	—	2	Guide rods	With swing bolster; lateral supports (rubbing blocks)	—	yes
Articul-ated sleeping car rake	Wegmann type Jakob bogie	2.0	900	2800	Helical springs	Helical springs	2.75	—	4	Guide rods	With swing bolster; lateral supports (rollers)	yes	—
Articul-ated day-service rake	Kruckenberg type two wheeled truck	—	900	2060	Helical springs and transversal rubber springs	Helical springs	3.50	—	2	Transverse rubber spring	With swing bolster; elastic struts	yes	—

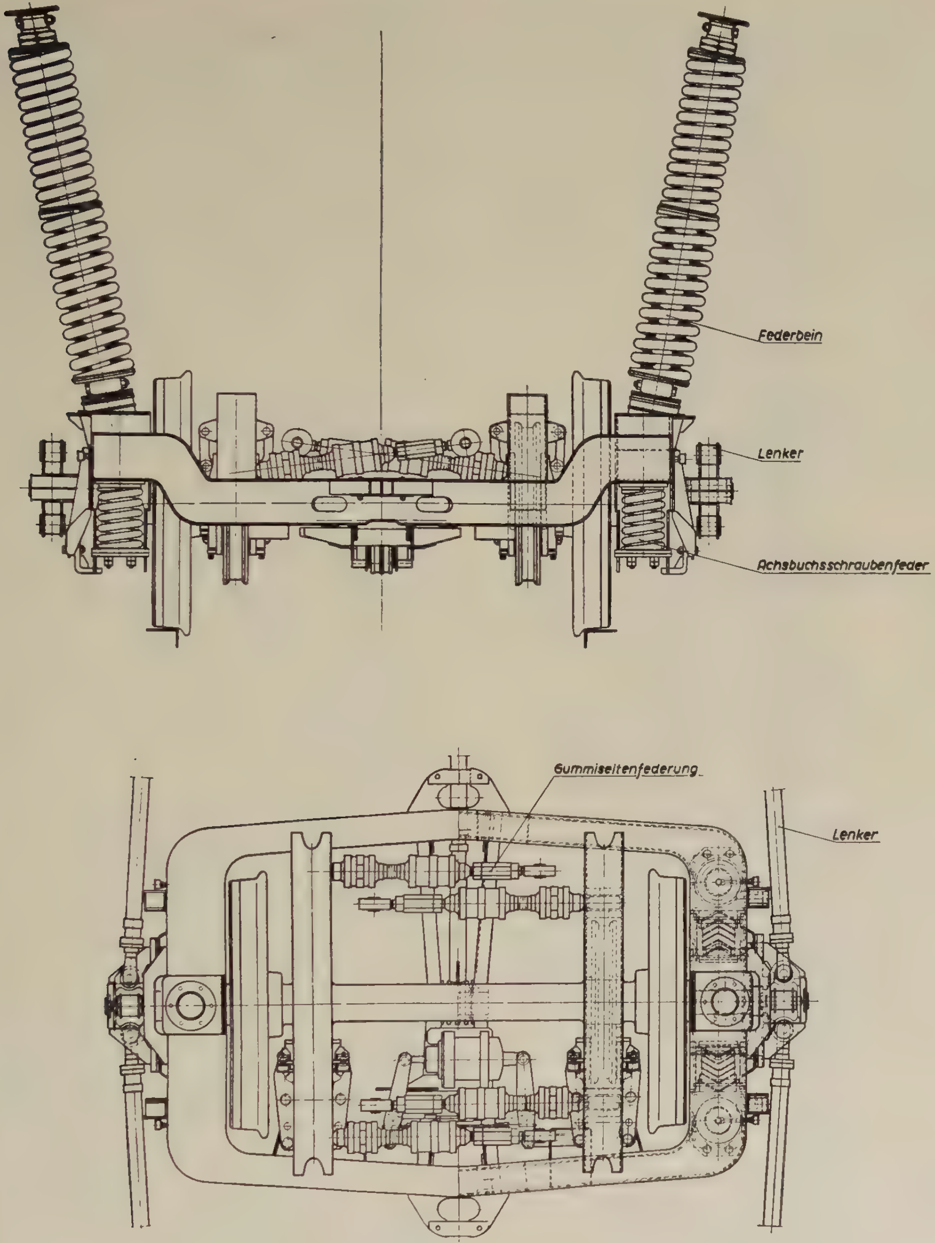


Fig. 1. — Two wheeled carrying truck of the articulated rake.

N. B. — Federbein = elastic strut. — Lenker = guide. — Achsbuchsschaubenfeder = helicoidal spring of axle box. — Gummiseitenbfederung = transversal rubber spring.

which is not accessible in service. The method of construction of the elastic strut has a radical influence upon the vertical running stability of the day service motor rake. The proper functioning of the coiled springs is only assured if the two parts of the telescopic tube can slide over each other with a minimum of friction, and if there is a sufficient gap between the springs, the telescopic tube and the shock absorber. In the new types of elastic strut, a central lubricating installation assures that oil is regularly applied to the sliding surfaces. In addition, care must be taken that when the elastic struts are fitted, no force can act obliquely on the telescopic guides.

The axles are mounted on coiled springs; a suspension with rubber springs between the axle box and the frame of the truck allows the axle to move transversely 10 mm each way when damped out by the springs. The frame of the truck is connected to the springs of the coach body by two transverse guides with rubber springs, which enable it to move 26 mm each way. It is too soon to estimate the results given by the transverse guides with rubber springs, especially as regards the useful life of the components of the rubber springs used.

It appears that the measures adopted for the construction of the bogies and two wheeled trucks are still not sufficient to assure satisfactory running in the case of the fast motor rakes even on track in an average state of maintenance, when the wear of the running gear has reached its limits for a given mileage, seeing that in the case of the fast motor rakes, it is necessary to be very strict about the running comfort, in which obviously the running quality plays a part. Measures intended to improve the running must also be applied to the body. Horizontal irregularities in the track due to the state of maintenance and the rail joints give rise to transverse shocks perpendicularly to the longitudinal axis of the track on the bodies of the coaches of a multiple unit, which move transversally as a result of these forces. The nature of the transverse movements of the bodies of the coaches depend in each case on the position of the running gear, either

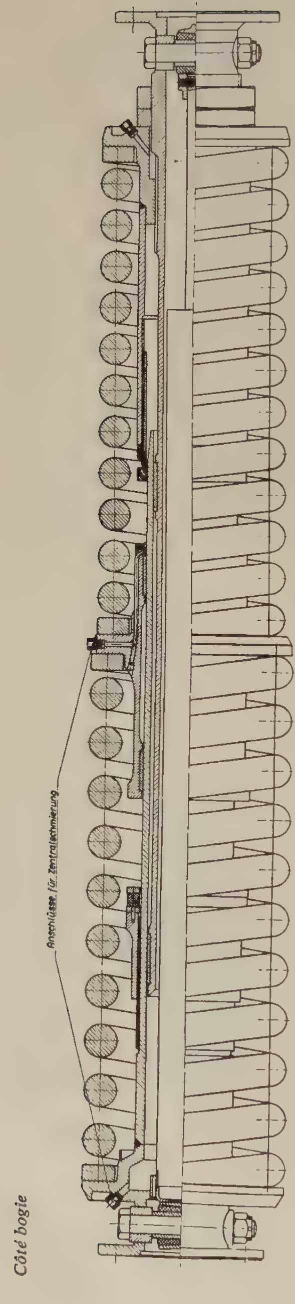


Fig. 2. — Elastic strut for the articulated rake.

N. B. — Drehgestellseite = bogie side. — Anschlusse für Zentralschmierung = joints for central lubrication.

under the main beams of the bodies (in the coach with two bogies) or at the ends when « Jakob » bogies are used. In the first case, the ends of adjoining bodies often move brusquely in relation to each other. The ends of the bodies of the coaches move with a scissors action. If the couplings are closely tightened up, or special friction gear is provided fitted with springs on the end walls above the door frames, transversal movements of the coach bodies could be damped out, even before the war. But such measures have the drawback of depending upon the care with which the coupling up has been tightened; in addition, when running through curves on the track, the friction stresses are modified. The measures in question have not made it possible to obtain any appreciable improvement in running stability, particularly at high speeds.

— — — = Position in case of transversal displacement.

Position when running on curve.

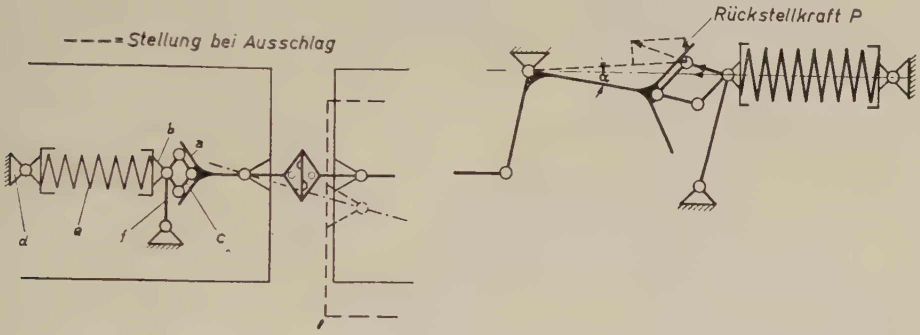


Fig. 3. — Arrangement of the stabilizer in the rakes with coupling with central buffer.

N. B. — Ruckstellkraft P = recentring force.

When « Jakob » bogies are used in the case of the sleeping car articulated motor rake and the two wheeled trucks of the day service articulated rake, the different coaches are joined together to form an articulated rake, the articulations of which are at the pivots. Under the action of the transversal shocks, the articulations are displaced transversally in relation to the axis of the track, so that the coaches all together make a hunting movement. The bodies of the coaches act in the same way when entering and running out of a curve on the track. In this case, the bodies form an angle corresponding to the curvature of the track.

In the case of the series 08 fast motor rakes built after the war, the transversal movements of the ends of the bodies of the coaches are to a great extent suppressed thanks to the installation of upper and lower stabilizers, and in the case of the articulated rakes, thanks to stabilizers fitted in the lower part. In the series 08 fast motor rakes, the lower stabilizers are fitted in the end headstocks of the body frame, and the upper stabilizers in the end walls of the close coupled ends, above the intercommunicating door frames.

The lower stabilizer (fig. 3) consists essentially of the bearing head *a*, the leading spring dish *b*, the two cranked levers *c* forming an articulated parallelogram, the rear fixed point on the body frame *d*, the stabilising spring *e* and the guide rod *f*. All pins exposed to wear are of St 70 steel case-hardened and ground, the sleeves being of « Ferrozell ».

The ends of the different bogie coaches of the series 08 motor rake are fitted with Scharfenberg centre buffer couplings, which are completely automatic. The stabilizer is fixed directly to the end, behind the automatic coupling pivot. The stabilizing device allows limited transversal movement of the coach bodies between each other on entering and leaving curves. On the other hand, it prevents transverse movement when running on the straight. If the coupling with centre buffer makes a movement in one direction, the levers c act as cranked levers. According to whether the movement is to the left or right, one or other of the cranked levers comes into play. As all the pivots are working under compression, there is never any play in the articulations. The cranked lever c compresses the stabilizer spring e through its bearing head a and the cup of the leading spring b. The guiding rod f acting on the cup of the leading spring serves for the guiding of the spring cup b. The stabilizers come into play whenever a transverse shock tends to displace the ends of the coach bodies from their central position (position when at rest). The tension of the spring of the stabilizer is calculated in such a way, taking into account safety as regards derailment, that the head of the automatic coupling can only be moved under the action of a transverse force of not less than 1.44 t. Such a transverse force will never occur when running on the straight. The coach bodies of the rake thus act as a closed tube. The recentring force of the stabilizer decreases as the movement off centre of the coupling increases. The restoring forces exerted at the end of the coach bodies decrease as the deviation increases, in other words as the radius of the curve decreases, in order to limit the wear of the flanges and rails and assure safety against derailment. The descending characteristic of the stabilizer spring makes it possible to apply considerable stabilising force when running on the straight. As the lower stabilizers are mounted behind the centre line on which the coupling with centre buffer pivots, no difficulty is experienced in coupling or uncoupling the coaches.

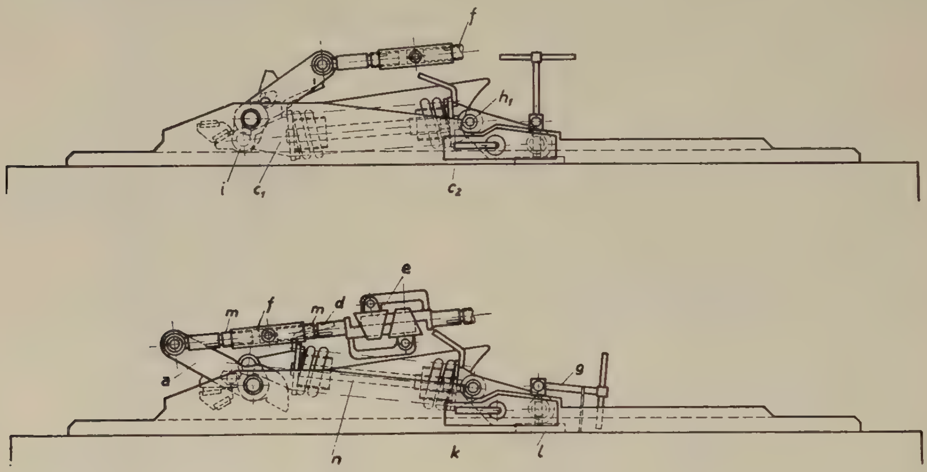
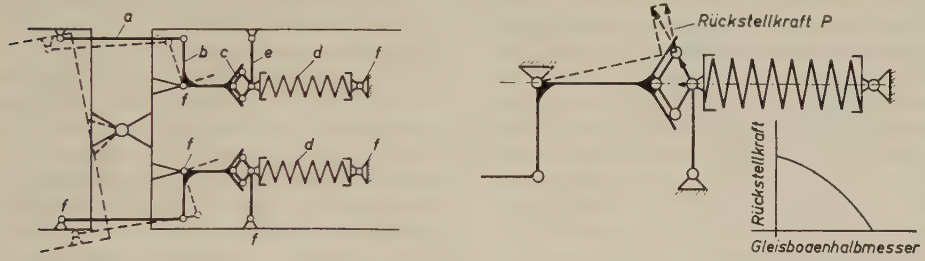


Fig. 4. — Upper stabilizer.

In coaches with a high centre of gravity, and when the coach bodies rest on bogies with inside axle boxes, the upper stabilizers, with the transverse stabilizers, help in reducing the rolling of the coach bodies. The upper stabilizer (fig. 4) consists essentially of the oscillating lever a, the stabilizer spring b, the front and rear spring heads c_1, and c_2, the two part connecting rod d, the tightening up sleeve e and tightener *f*, the tension screw of the spring *g*, the axis of inversion *h*, the small oscillating lever *i*, the rear oscillating lever *k*, the stop *l*, the stop device *m* and the regulating screw of the spring *n*. Here again all the pins exposed to wear are of St 70 steel case-hardened and ground; these pins turn in « Ferrozell » bushes. Lateral movements of the body are transmitted by the tie rod *f* to the oscillating lever *a*, which extends the stabilizer spring. This is under compression when the pivoting force is above 480 kg (1 058 lbs.). Coupling and uncoupling require a certain degree of skill, but can be carried out in a few minutes without difficulty, so that the upper and lower stabilisation never prevents coaches being added or taken off in the stations. Coupling up must be done on lines without superelevation. The upper stabilising device is lubricated by means of a central greasing device, the lower by an oil lubricator which also supplies the rubbing parts of the Scharfenberg automatic coupling, which must always be maintained in a properly lubricated condition which prevents wear of the pivots to a great extent.



Arrangement of the stabilizers on the articulated rakes.
——— = fundamental position (on the straight).
– – – = position on curves.

Cinematic of articulated parallelogram.
Position when running on the straight.

Fig. 5.

N. B. — Rückstellkraft = recall effort. — Gleisbogenhalbmesser = radius of curvature of the track.

In the articulated rakes on « Jakob » bogies or two wheel trucks, the stabilising equipment fitted in the frame keeps adjoining coach bodies under a tension of 2 700 to 3 000 kg (5 952 to 6.613 lbs.) exerted by helical springs. On straight, level track, the whole rake therefore behaves like a single rigid body. The influence of transverse movements of the « Jakob » bogies or two wheel trucks due to the bad state of repair of the track are therefore eliminated to a great extent. In this way, effective stabilisation of the running is obtained on the straight even of the highest speeds. When running through curves, the recentring effort of the stabilizer spring opposes to the inscription of the different parts of the coach in the curve a resistance which decreases with the radius of curvature of the track. Without this precaution, the pressure of the wheels might increase on curves excessively so that too high a stabilising force would increase the risk of derailment.

The stabilising device fitted in the articulated rakes (fig. 5) consists of the traction rod *a*, the large cranked lever *b*, the articulated parallelogram *c*, the stabilising spring *d*, the spring guide *e* and the fixed points *f*. The recall force P due to the arrangement of the rigging has been represented for the two cases : running on the straight and through curves. The graph shows the relation between the recentring efforts and the radius of curvature of the track. It will be noted here again that the recentring force decreases considerably on curves.

In practice, it was found that the bogie railcars whose sets of wheels are fitted with guide rods without play in the longitudinal direction (series 08 and articulated rakes) had much better running qualities in the horizontal sense, perpendicularly to the centre line of the track, than the Koln type fast railcar with « Görlitz » bogies with « Verein » type guidable axles. With this type, stability of running deteriorated appreciably after a mileage of 77 000 km (29 205 miles). On the vehicles equipped with guide rods, on the contrary, no appreciable reduction in transverse stability of running was noted after a mileage of 150 000 km (93 000 miles).

In addition, experience in service showed that on the bogie coaches without swing bolster and with axle guide rods, an appreciable increase in transverse running stability was obtained compared with the old types of railcars with swing bolster and without guide rods. The articulated motor sleeping-car rake with « Jakob » bogies with swing bolsters and guide rods gave the best transverse stability with an oscillation frequency of 1.0. The combination of this type of bogie and guide rods has made this one of the best vehicles of the Deutsche Bundesbahn from the point of view of the frequency of horizontal oscillations and running qualities. The table shows the influence of hydraulic shock absorbers on horizontal stability of running; here again the vehicles with oil shock absorbers are the best, provided that such shock absorbers are working perfectly.

The much better transverse running qualities of the railcars with axle guide rods must be attributed to a large extent to the stabilising gear with which they have been equipped. When measurements were made during running on the long distance series 08 railcar, it was found that transverse stability of running was improved by 0.4 to 0.6 units thanks to the introduction of stabilizers. The stabilizer have no effect on vertical stability of running. The triple long distance series 08 railcar consists of a motor unit, an intermediate coach and a coach with driving compartment. According to the direction of running, the last two are either hauled or pushed. Measurements have shown that the value of transverse stability was 0.2 units better in the hauled rake than in the pushed rake. This difference must be ascribed to the centre buffer coupling which favours transverse mobility of the ends of the coupled coaches when the rake is being pushed. In rakes with the standard draw and buffer gear, there is no reduction in the quality of running when the rake is pushed because the side buffers when compressed have rather a tendency to damp out still further any transverse movement of the ends of the coaches.

Vertical stability of running is a function of the frequency of oscillation of the coach itself, which can be calculated approximately by the formula $f = \frac{1}{2\pi}\sqrt{\frac{c}{m}}$ In this formula, c represents the elastic constant and m the reduced mass of the coach. Good vertical running stability is obtained when the actual frequency does not exceed 1 Hz. The elastic constant depends on the flexibility of the springs. This is found by taking the flexibility of the coach in cm/t, in other words the deflection of the springs in cm compared with the weight of the coach in tons. This deflection cannot be selected in an arbitrary way, as it must be comprised in the interval between the maximum and minimum height of the buffers with worn tyres, in other words between 1 065 mm (maximum height, i.e. the empty coach on wheels with new tyres) and 965 mm (minimum height, i.e. the fully loaded coach with worn tyres). The maximum flexion admissible cannot therefore exceed 100 mm. The only exception to this rule are vehicles fitted with couplings with centre buffer when these are formed into rakes which are not hauled by traction units fitted with standard traction and buffer gear. Such an exception had to be made in the case of the articulated day service rake with which a flexion of 170 mm was necessary to obtain sufficiently good running qualities. The total flexion consists of the flexion of the suspension of the boxes and that of the suspension of the body. Experience has shown that in order to obtain a satisfactory running stability, it is desirable that in the case of bogies the suspension of the wheel sets should supply 20 to 30 % of the total displacement, and the suspension of the body 80 to 70 %, in other words that the suspension of the wheels should be hard and the suspension of the body soft. With such a subdivision, the suspension of the boxes will mainly absorb the shocks, and the suspension of the body, which is softer, the low frequency vertical vibrations set up by the track. It is the choice of the suspension of the body which has the greatest influence upon the running stability of a vehicle.

The hardness of the suspension of the box is limited. It must be calculated in such a way that the bogies, as well as the motors and equipment mounted thereon, are not submitted to excessive stresses, and so that the brake rigging is not noisy. A hard suspension of the box in particular has the advantage of preventing to a great extent hunting movements of the bogie. It is necessary to design the bogie frame and calculate the sections of the beams in such a way that they do not yield under the influence of the maximum stresses imposed on them, that they remain undeformed diagonally, and cannot twist, so that the parallelism of the axles and their perpendicularity to the centre line of the track remain unchanged under all circumstances.

As the formula for f given above shows, the elastic constant must be correctly proportioned to the mass of the vehicle. It follows that in the case of a heavy vehicle, a hard suspension, i.e. a low value of c, has less effect upon vertical running stability than in the case of a light vehicle. The light vehicle must have more flexible springs. In the heavy vehicle, the influence of the useful load is less than in the case of vehicle of light weight construction. In the case of fast railcars, however, this influence is less apparent, because the number of passengers is, owing to the greater length of the compartment, smaller than on standard passenger trains, and still more than in the case of the workmen's trains, where there will be many standing passengers, which are not used in fast, long distance traffic.

The bogies of the types of fast railcars built since the war now only have helical springs. As such springs do not have sufficient damping out power of their own, it is essential to fit shock absorbers working as a function of the speed to prevent oscillations of the coaches. Such oil shock absorbers are not necessary on the axle box bearing springs, because of their hardness. The different types derived from motor designs are often wrongly called shock absorbers. This name is inaccurate, because if the shock absorbers are not correctly adjusted, the shocks are on the contrary actually increased. Shock absorbers damping out vibrations are an undesirable additional component on the bogie in themselves, not only on account of their cost and their weight, but also because they are very liable to get damaged, in particular on account of their lack of air tightness and the faulty working of the valves, etc. If they are not air tight, the air gets into the interior and reduces the damping out effects. The working of these parts results in internal friction. None of the shock absorbers at present on the market can be adjusted or corrected in service. Defects in their air tightness are only shown by traces of oil on the outside. Often the shock absorbers are fitted in the most inaccessible parts of the bogie, sometimes even inside the helical springs, which makes it difficult to see when they are damaged, so that damage is only detected when the stability of the running is affected.

The working of the helical springs should not be hindered by the mutual friction of the bogie components and the springs themselves. Any rubbing affects running stability. When designing the bogies, care must be taken to avoid any points likely to cause friction. Helical springs must be kept short enough to be sufficiently protected against any lateral instability and no telescopic guides should be needed. Perfect lubrication of the sliding surfaces presupposes an automatic central lubricating device, seeing that the parts that need lubrication are often difficult of access and consequently cannot be properly greased by hand. To make sure that no dirt can affect the lubricated rubbing points, the telescopic tube is surrounded by a leather bellows. Running experience has shown that vertical running stability has been improved in the different types of railcars by increasing the flexibility and reducing the frequency of oscillation. If the day service articulated rake does not show the best running stability in spite of the fact that the flexibility of its suspension is the softest (3.5 cm/t), this circumstance must be attributed solely to the constructional design of the elastic strust, taking siting conditions into account. With this design in fact it was not found possible to provide the amount of flexibility theoretically required, and the inevitable rubbing that results affect the proper functioning of the spring. The articulated sleeping-car rake is better than the other types of motor rakes from the point of view of vertical stability as well, and this must be attributed to the care taken in calculating the springs as well as to the lightness of the bogie, which is very well proportioned to the lightness of the body. Up to now, it has not been possible to go below figures of 1.8 for the horizontal stability and 2.0 for the vertical stability, even on the heavy passenger coaches. The articulated sleeping-car rakes are therefore a definite proof that it is inaccurate to pretend, as it so often is, that vehicles of light weight construction necessarily have poorer running qualities; the use of appropriate constructional methods makes it possible to obtain good running qualities even on such vehicles.

Coach bodies.

The weight per rake for the different types of fast railcars have been grouped synoptically in Table 5, being given separately for the coach and the motor part. The small powers of the traction motors especially when the first rakes were built (410 HP) and the high speeds required (160 km/h) made it necessary to limit the weight of the rake to the minimum and to design its outward form according to aerodynamic principles in order to reduce air resistance. Nor did the need to restrict the weight become any less imperious when the power was increased to 1 000 HP, as this increase in power was wiped out by the need to increase the capacity of the rakes. Even with the first railcars of the « Hamburg » type, there were coaches with an installed power of 2 × 410 HP which did not weigh any more than comparable passenger coaches of the period. The series 08 fast triple railcar with a weight in service of 120.45 t and a length of 80 m does not weight much more than three of the lightened B 4 Ü express coaches of a length of 26.4 m, although on the rake there is a mechanical installation weighing 19.74 t and 4.5 t of service equipment and supplies.

All the types of fast railcars from the « Flying Hamburger » to the series 08 railcar are of welded steel construction. Whereas to begin with welded sections were used on the same lines as in passenger coaches, in the series 08 railcar for the first time thin welded plates were used, combining the tubular and Vierendeel types.

The saving in weight is considerable (about 36 % compared with the Cologne type fast triple railcar which preceeded it). A further reduction in the weight can be obtained by the use of light metals, using a type of construction derived from the tubular and Vierendeel types of the series 08, which was used for the first time on the day service articulated rake. Whereas with the series 08 fast railcar the weight of the rake per metre run amounts to 1.52 t, it has been reduced to 1.22 t/m on the articular day service rake. Experience obtained with this method of construction in light alloys shows that it is only necessary to use ST 37 steel for the main frame longitudinal from the coupling with central buffer as far as the main crossbeam, and for these crossbeams, all the rest being made of light metals. However, the light metal parts must be carefully designed in order to simplify fabrication to the utmost as well as the assembly, in order to compensate for the high cost of light metals.

TABLE 5. — **Weight of the rakes.**

	Type of railcar	Weights in tons									Length of rake in m	Number of seats	Weight in t per		Motive power in HP	Motive power per t of weight of the train
		Vehicle					Mechanical equipment	Weight of rake when empty	Stores	Weight in service			m run of the coach	seat		
		Motor unit 1	Motor unit 2	Unit with a driving cab	Inter-mediate coach 1	Inter-mediate coach 2										
1	SVT 04.1 double « Flying Hamburger »	26.66	26.66	—	—	—	21.1	74.42	4.23	78.65	41.906	65	1.9	1.2	820 780	10.4 9.9
1*a*	SVT 04.1 double Hamburg type	32.0	32.0	—	—	—	23	87	4.23	91.23	44.256	76	2.03	1.2	820 760	8.9 8.3
2	Triple SVT Diesel-electric Leipzig type	34.92	34.92	—	26.53	—	31.29	127.66	5.34	133.0	59.650	139	2.43	0.95	1200 1140	9.0 8.5
2*a*	The same, Diesel-hydraulic	34.9	34.82	—	26.44	—	22.3	118.66	5.34	124.0	59.650	139	2.07	0.885	1200 1120	9.7 9
3	Triple SVT Diesel-electric Cologne type 06.1	44.025	44.225	—	41.270	—	33.205	162.725	4.855	167.586	69.505	102	2.42	1.6	1200 1120	7.5 7
3*a*	The same, Diesel-hydraulic 06.5	44.945	42.845	—	41.730	—	24.925	129.52	4.855	159.3	69.505	102	2.15	1.53	1200 1120	7.5 7
4	Four unit SVT Berlin type	Motor unit 38.497	—	39.854	38.685	39.365	51.906	208.307	4.793	213.1	86.755	126	2.47	1.7	1300	6.1
5	Triple VT 07.5 ex-Berlin	36.610	—	40.512	38.278	—	25.8	141.2	4.800	146.0	69.04	102	2.1	1.43	1000 928.4	6.88 6.33

TABLE 5. — **Weight of the rakes.** *(continued)*

<table>
<tr><th rowspan="3" colspan="2">Type of railcar</th><th colspan="12">Weights in tons</th><th rowspan="3">Length of rake in m</th><th rowspan="3">Number of seats</th><th colspan="2">Weight in t per</th><th rowspan="3">Motive power in HP</th><th rowspan="3">Motive power per t of weight of the train</th></tr>
<tr><th colspan="8">Vehicle</th><th rowspan="2">Mechanical equipment</th><th rowspan="2">Weight of rake when empty</th><th rowspan="2">Stores</th><th rowspan="2">Weight in service</th><th rowspan="2">m run of the coach</th><th rowspan="2">seat</th></tr>
<tr><th colspan="2">Motor unit 1</th><th>Motor unit 2</th><th colspan="2">Unit with a driving cab</th><th>Inter-mediate coach 1</th><th colspan="2">Inter-mediate coach 2</th></tr>
<tr><td>6</td><td>Triple VT 08.5 long distance 1 000 HP</td><td colspan="2">36.894</td><td>—</td><td colspan="2">29.866</td><td>29.450</td><td colspan="2">—</td><td>19.740</td><td>115.95</td><td>4.50</td><td>120.45</td><td>79.250</td><td>114</td><td>1.52</td><td>1.06</td><td>1000
928.4</td><td>8.35
7.8</td></tr>
<tr><td>7</td><td>The same. Four unit power : 2 000 HP</td><td colspan="2">36.894</td><td>35.890</td><td colspan="2">—</td><td>29.450</td><td colspan="2">29.450</td><td>33.91</td><td>165.596</td><td>7.520</td><td>173.116</td><td>105.98</td><td>162</td><td>1.63</td><td>1.07</td><td>2000
1870</td><td>11.6
10.4</td></tr>
<tr><td>8</td><td>The same. 5 coaches 2 000 HP</td><td colspan="2">36.894</td><td>35.890</td><td colspan="2">VM 3
29.450</td><td>29.450</td><td colspan="2">29.450</td><td>36.70</td><td>197.83</td><td>8.36</td><td>206.19</td><td>132.21</td><td>222</td><td>1.56</td><td>0.93</td><td>2000
1863</td><td>9.7
9</td></tr>
<tr><td>9</td><td>Articulated day service rake with 7 coaches VT 10 501</td><td>VT*
19.550</td><td>VM 1**
10.404</td><td>VM 2
10.602</td><td>VM 3
7.799</td><td>VM 4
10.454</td><td>VM 5
10.548</td><td>VM 6
—</td><td>VT
20.689</td><td>20.950</td><td>110.996</td><td>6.995</td><td>117.991</td><td>96.2</td><td>131</td><td>1.22</td><td>0.9</td><td>840</td><td>7.12</td></tr>
<tr><td>10</td><td>Articulated 8 sleeping-car rake VT 10 551</td><td>VT
16.883</td><td>VM 1
9.185</td><td>VM 2
9.640</td><td>VM 3
9.490</td><td>VM 4
8.885</td><td>VM 5
9.124</td><td>VM 6
9.022</td><td>VT
17.170</td><td>23.244</td><td>111.703</td><td>6.837</td><td>118.540</td><td>108.4</td><td>82</td><td>1.09</td><td>1.47</td><td>840</td><td>7.06</td></tr>
</table>

*VT = motor unit.
**VM = intermediate unit.

The most rational shape for the outside of the railcar was determined by tests in the wind tunnel. It appeared that in designing the exterior shape, care must be taken to make the outside of the railcar as smooth as possible, without any projections or hollows. The ends of the rakes were made very round and the roof of the coaches lowered towards the ends of the coaches. It also appeared necessary to reduce to the minimum the space under the vehicles, between the bogies and the ends, as well as in front of the bogies, and to make it smooth, in order to avoid air eddies. For this reason with the series 08 fast railcars a much lowered false floor with side petticoats and a continuous sheeting for the false floor between the two petticoats had to be used. The coupled ends of the vehicles and their intercommunicating gangways are covered in with a thin rubber sheeting which completely encloses the gangway. Figure 6 shows the front end of the series 08 fast railcar.

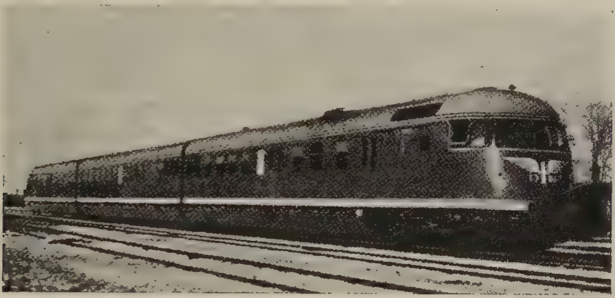


Fig. 6. — Front end of series 08 fast railcar.

As a general rule the driving compartments on the railcars are immediately behind the front wall of the body. This arrangement has the very great advantage that thanks to the windows all round the front of the coach, the driver has a completely unobstructed view of the track in front of him and to the sides. He is thus in a position to brake very quickly whenever an unexpected danger crops up on the track. It is not always possible to prevent the driving compartment being damaged should a collision occur at speed. For this reason a means of escape is provided at the back of the compartment for the protection of the driver. Even if he remains in the corridor of the engine room which is immediately behind the driving compartment, he is in practice shielded from any danger due to the driving compartment being driven in. Recently, the driving compartments have been set back a little towards the rear. The bonnet, of varying size, which may be damaged without inconvenience if a collision occurred, protects the staff who are in the setback driving compartment very effectively. With this arrangement, the driving compartment is raised up in order to give a sufficiently clear view of the track, which is partly hidden by the bonnet. Set back driving compartments were introduced for the first time on the two articulated rakes. Even with the raised up position of the driving compartments, the ends of the coaches can be shaped in such a way that the air resistance is not increased.

Draw and buffing gear.

The coaches of the fast railcars have been equipped, both at the ends of the rakes and between the different units, with couplings with a central buffer. This assures automatically not only the coupling up of the rakes and different coaches, but all the coupling up of the brakes pipes and electric cables for the train control.

In the series 08 fast railcars, the couplings with central buffer are connected to the stabilising equipment. The coupling with central buffer fitted at the ends of the rake replaces the side buffers which interfered with the streamlined form of the ends. During trials on the line, it was found that side buffers increase the air resistance considerably; their suppression makes it possible to save about 14 HP for each end of the rake.

Height of the coaches.

The height of the fast multiple unit railcar coaches, up to the series 08 inclusive, varies between 3 710 and 3 900 mm above rail level. On the other hand the units of the articulated rakes are 3 525 mm above rail level, i.e. 375 mm lower than the other railcars. As their width is about 20 cm greater and their floors are lowered as much as 850 mm, the cross section of these units is still greater than in the other railcars up to the series 08. The centre of gravity of the articulated rakes above rail level is lower, which increases safety against derailment and reduces rolling during running. The transversal surface of the coaches of the articulated rakes assures lower air resistance than that of the rakes with high coaches, especially on account of the fact that the side walls slope obliquely upwards.

Width of the coaches.

The width of the coaches depends, as is known, on the distance between bogie pivots and the overhang at the ends. The outside width of the body of the coaches of the fast railcars varies, as Table I shows, between 2 859 and 2 814 mm. The inside width of the body, which is what interest the passengers, varies between 2 706 mm in the Cologne type and 2 652 on the « Flying Hamburger » type. Apart from the railcars with « Jakob » bogies, the coaches of the series 08 have the smallest inside width (2 694 mm) because of the pivot spacing of 19 m used for the first time in the construction of these fast railcars. Increasing the spacing to 19 m in this way made it possible to house conveniently in the trough of the double floor (Bodenwanne) between the bogies all that part of the motor installation which could not be fitted on the motor bogies. Including the overhang, a body length of 26.025 m has thereby been obtained in the case of the motor and driving compartment coaches and 25.76 m in the case of the intermediate coaches. The proportion of the bogies in relation to the length of the rake is definitively less in these railcars than on the shorter railcars. This type of construction consequently results in economies in the purchase price and maintenance costs.

However limiting the inside width of the coaches to 2 694 mm is detrimental to the passenger's comfort to some extent, especially on the coaches with separate compartments. The interior width of the compartment is 1 900 mm in this case, the corridor being 775 mm wide. This gives a seat width of 633 mm, including the elbow rests. As passengers on the fast railcars often have a long journey, such as Dortmund-Paris or Hamburg-Zurich, this reduction in the comfort is justly criticised by them when it is remembered that they have paid for a first class ticket plus the supplement for long distance trains. On the articulated rakes, on the other hand, the length of the body is 11.8 m, the outside width 3 025 mm and the inside width 2 890 mm. The articulated units are therefore 206 mm wider than the series 08 fast railcars, and this extra width is used to increase the width of the seats.

As we have already remarked, the coaches of the articulated rakes have no overhang, since they are mounted on « Jakob » bogies, or on two wheeled trucks between the units. If each of these units were mounted on two bogies, the bodies could be extended at the two ends by an amount equal to the overhang. With a pivot spacing of 12.6 m and a body width of 3 012 mm, the overhang could be made 2.4 m long, which would make the total length of the coach body 17.4 m. A coach body of this type from the point of view of the width would be practically as comfortable as the articulated rakes.

TABLE 6. — **Factors determining the comfort.**

	Type of railcar	Height of coach	Level of floor	Type of passenger compart.		Number of seats			Arrangement of seats	Seat spacing (compartment length)	Guards compartment	No. of entrance doors	Length of door openings	No. of toilets	Dimensions of toilets	Buffet-kitchen-office	Dining room		Type of heating	Mail comp.	Luggage comp.
				One large open compartment	Separate compartments	Large open compart.	1st class compart.	Total									Length	No. of seats		Length m	Length m
1	SVT 04.1. double « Flying Hamburger »	3710	1280	100%	—	65	—	65	2+1	1800	yes	3	1180	2	1530/995	Kitchen	—	—		—	2.78
1*a*	SVT 04.1. double Hamburg. type	3775	1280	100%	—	76	—	76	2+1	1800	no	3	1180	2	1300/995	Buffet	—	—		—	3.6
2	Triple Diesel-electric Leipzig type	»	»	60%	40%	2^{e} cl 109	30	139	0+3 0+4	1990 1600	no	4	1100	4	1540 × 1000 1360 × 1400	Kitchen	—	—	A water	1.8	3.31
2*a*	The same Diesel hydraulic	»	»	»	»	»	»	»	»	»	»	»	»	»	»	»	—	—	»	»	»
3	Triple SVT Diesel-electric Cologne type	3775	1280		100%	—	102	102	0+3	2060	no	4	1270/1100	3	1000/1320	Kitchen	8.5	30	A water	—	4.2
3*a*	The same, Diesel-hydraulic	»	»		»		»	»	»	»	»	»	»	»	»	»	»	»	»	—	»
4	Four unit SVT Berlin type	3823	1090	—	100%	—	126	126	0+3	2075	yes	4	1425/1130	4	1425 × 1196 1300 × 1000	Kitchen Office	8.5	29	A air	2.8	3.2

TABLE 6. — **Factors determining the comfort.** *(continued)*

Type of railcar		Height of coach	Level of floor	Type of passenger compart.		Number of seats			Arrangement of seats	Seat spacing (compartment length)	Guards compartment	No. of entrance doors	Length of door openings	No. of toilets	Dimensions of toilets	Buffet-kitchen-office	Dining room		Type of heating	Mail comp.	Luggage comp.
				One large open compartment	Separate compartments	Large open compart.	1st class compart.	Total									Length	No. of seats		Length	
																				m	m
5	Triple SVT 07 ex-Berlin	3823	1090	—	100%	—	102	102	0+3	2000/2075	no	4	1270/1100	3	1000/1320	Kitchen	8.5	29	A water	—	4.875
6	Triple VT 08 long distance	3900	1550	—	100%	—	104	114	0+3	2060	yes	6	1175	3	1470/1087		6.8	24	A water	1.45	3.64
7	The same, 4 units	»	»	—	100%	—	162	162	0+3	»	»	8	»	5	»	Kitchen and Office	»	»	»	»	»
8	The same, 5 units	»	»	—	»	—	222	222	»	»	»	10	»	7	»		»	»	»	»	»
9	Articulated day service rake with 7 coaches VT 10 501	3375	900	100%	—	131	—	131	1+2	2300	yes	5	1100/1200	4	1400/1100	Kitchen and Office	—	—	Air conditioning equipment	—	2.82
10	Articulated sleeping-car with 8 coaches VT 10 551	3525	850	40%	60%	34	48	82	1+2	2650 1350	yes	5	900/1150	11	1290 × 1000 1065 × 1000	yes	Bar 3200			—	2.75

The main dimensions of the different types of fast railcars are mentioned in Table 6 in order to give an idea of the degree of comfort provided. The table shows that in the « Flying Hamburger » the seats are still only 1 800 mm apart. This narrow spacing was only admissible on account of the shortness of the journey (the « Flying Hamburger » runs on the Berlin-Hamburg line). When fast railcar services were introduced on long runs (for example Berlin-Cologne), the space between seats was increased to about 2 000 mm, in order to allow passengers to stretch their legs without interfering with the person facing them. In the series 08 fast railcars, the seat spacing is 2 060 mm. The seats of the fast railcars cannot be extended; they have no position in which passengers can sleep, as this was not considered necessary at the time because such rakes only run on the day services. Experience has taught us, however, that passengers were unanimous in wishing for extendable seats even in rakes running during the day. Adjustable seats were fitted for the first time on the articulated day service rakes. The spacing of 2 300 mm adopted on these rakes is due to the fact that meals are taken on movable tables which must have a certain width.

Abroad, even wider seat spacings are sometimes found (up to 2 500 mm) When the seats are too far from each other, conversation between passengers facing each other may be disturbed by the running noises. The spacing of the seats, and consequently the length of the compartments has a primordial effect upon the seating capacity of a coach; this is why there is a tendency to limit the seat spacing as much as possible, in order to get an adequate user. This tendency is however itself limited by considerations of comfort. In the fast railcars, the seat spacing in compartments where no meals are served must not be less than 2 200 mm and the seats should be extendable.

Floor height.

The floor height of the fast multiple railcars varies between 1 280 and 1 150 mm. In the case of the articulated rakes, the floor height is only 850 or 920 mm, thus making it possible to do away with a step inside and consequently simplify the construction of the frame. To avoid accidents, it is impossible to avoid covering in inside steps, but it is difficult to do this in the case of stairs with several steps.

In the June 1953 issue of the « Bundesbahn », Professor Dr. Ing. **FROHNE** went in great detail into the question of the importance and advantages of low floors in coaches used for passenger transport in his article « Articulated motor rakes for long distance services ».

In view of the regulations in force, the diameter of the running circle of the wheels must not be less than 840 mm. A floor height of the order of 900 mm is only possible if sufficiently large covers are allowed to protect into the coach to cover over the wheels. Their height is affected by the height of the longitudal girders of the body frame, the floor covering, the thickness of the sound insulation, and the flexibility of the suspension. Their width depends upon the transversal movements of the axles in relation to the body of the coach. The arrangement of a coach with wheel covers projecting into the compartments must be designed in such a way that such covers will not inconvenience or endanger the passengers in any way. The design of the coach is therefore restricted to this extent.

In his article « Diameter of wheels and height of the flanges » published in the *Eisenbahntechnische Rundschau,* No. 12, 1955, **SCHRAMM** as a result of a new and fully developed study, has established new bases for estimating the possibility of using smaller wheels. He came to the conclusion that in the case of vehicles of the usual design, the diameter of 850 mm now laid down on the Deutsche Bundesbahn could not be reduced below 705 mm, if the present mileages without wheel truing were not to be reduced. **SCHRAMM** shows in this way, by his method of calculation, the methods that could be followed to reduce to a minimum of approximately 700 mm the diameter of the tread previously used.

Owing to their increased speed of rotation, small wheels like this require larger axle boxes if there are to last sufficiently well. It is possible to fit brakes discs of sufficient size in the centres of the smaller wheels. The introduction of such small wheels on light short coaches, the load per wheels of which is appreciably smaller, does not give rise to any objections as regards increased wear of the tyres and rails. The adoption of these small wheels depends however on the granting of permission to set aside the present Regulations on the construction and working of railways and the modification of the international regulations concerned. Wheels with a minimum diameter on the tread of 700 mm would make it possible to do away with the wheel covers projecting into the interior of the coaches, even with a low floor.

Interior arrangement.

The idea of the « comfort of the passenger » is often erroniously confused with that of « luxury ». « Luxury » on passenger trains has been banished owing to the high cost of construction and maintenance it involves, the difficult financial position of the railway, social considerations and other similar reasons. Assuring a proper standard of comfort consists essentially in arranging the interior of the coaches with taste and making available to the passenger sufficient space to assure that he will have an agreeable journey, even when it is a long one. The creation of an aesthetic interior arrangement obviously means taking greater care in designing it and the employment of an architect-decorator who is familiar with the construction of vehicles, yet it need not cost any more than a tasteless installation. Extra cost is involved, it is true, owing to the increase in the amount of space available, due to increasing the length of the compartments, and the width of the seats, and including office-compartments, radio, kitchens, dining-rooms and toilet compartments. The softness of the seats can be increased by using foam-rubber without involving increased constructional and maintenance costs, nor reducing the life of the seats. Additional expenditure is required in addition for fitting sufficient sound proofing, and for double windows to avoid condensation. Additional costs are also involved for air conditioning installations. These increased costs will be made good to some extent by the possibility of using fixed windows which cost less. In addition, the air conditioning plant does away with such inconveniences for the passengers as smoke, dust, etc.

Air conditioning equipment only involves additional operating costs, on the whole, when used for cooling. The measures intended to assure satisfactory running do not lead to any appreciable extra costs. They are moreover necessary quite apart from considerations of comfort, seeing that rakes with satisfactory running qualities save the vehicles themselves and the track, and thus reduce maintenance costs. The fitting of kitchens and restaurants in long distance rakes has been the current practice for many years and cannot be omitted on the existing long coaches, where moreover they are not considered to be an excessive luxury.

The comfort of the long distance rakes, which we have broadly sketched in, has been kept within reasonable limits, and is far from representing excessive luxury. It simply assures that the passenger will be at ease during the journey, and will find it not a fatigue but an interlude, during which he can even carry on with his work if he wants to and dictate to the train typist. In the United States, in the express trains the standard of comfort is intended, much more than in Europe, to satisfy the requirements of blasé passengers. In this country, the well-off businessman uses the long distance express train rather than the aeroplane. In America, the long distance trains have been introduced not solely to satisfy luxury requirement, but to improve the profitability of the lines thanks to the receipts they bring in.

In this connection it may be remembered that already before the first world war, first class coaches on the German lines only consisted of two seats side by side (seat arrangement 0 + 2). In the same way, on the « Rheingold » after the first world war, in the first class compartments there were only two seats on either side (seat arrangement

1 + 1). In this case the passenger could always have a window seat. In view of the fact that since the introduction of the 1956 summer timetables, the system of two classes has also been introduced on the European services, and upholstered seats have been retained for the lower class, it does not seem possible to make any distinction in the comfort of the two classes unless there is a return in the case of the first class compartments to a seating arrangement of 0 + 2 or 1 + 1, in other words going back to what was formerly offered to satisfy the demands fo the exacting travellers. It seems to be an undisputed fact that this standard of comfort is the most effective competition against the private motor car and the aeroplane in the case of the long distance European train services. The additional capital needed for these railcars is not so great as to have any appreciable effect upon their profitability. No doubt the hour has not yet come when such a high standard of comfort in travelling needs to be introduced in Europe, but is seemed opportune to allude to the possible evolution.

In many quarters, there is a very mistaken idea about the true influence of the comfort of the journey on the cost of hauling the trains. It must be pointed out first of all that the influence of the sinking fund becomes the smaller the greater the annual mileage of a rake. The fast railcars run long distances every day. For example, the average daily mileage over the year for a series 08 triple railcar is about 1 100 km (682 miles), so that the annual mileage amounts to 200 000 to 250 000 km (124 000 to 155 000 miles). In view of the great reliability of working of the Diesel engines, the mileage run between two overhauls in the shops amounts to some 300 000 km (186 000 miles). In an extremely carefully worked out study, STROEBE established that owing to the very high mileages run by the Diesel railcars, amounting to approximately 250 000 km a year, an additional capital cost of 20 % only increases the traction costs per seat by some 3 %, an additional cost which seems to be perfectly justified for such a considerable increase in the comfort of the journey, and in addition gives it an advantage over the private motor car and the aeroplane against which neither of these can hope to compete. In this question of the standard of comfort to be adopted, it must also not be forgotten that the new railcars which are to be built must for economic reasons have a useful life of at least 20 years, i.e. after 10 years their comfort must still be of a sufficiently high standard to overcome all competition.

There is no doubt that the standard of comfort which we have sketched above has an attraction for the travelling public. Doubtless there are no statistical data making it possible to calculate the influence of the standard of comfort offered. But if during the course of recent years railway passenger traffic has generally increased, the improvement of the rolling stock, and in particular the interior arrangement of the stock, in other words the increased comfort of the journey, has played an important part in this. It is possible to debate the point whether in the case of trains for a special class of traveller (workmen, etc.) an increase in the comfort would lead to increased receipts. In the case of long distance traffic, especially in the case of the fast railcars, a reasonable increase in the standard of comfort is essential if it is desired to keep the present clientele, or even increase it, in view of the competition of the private motor and the aeroplane. Nor must it be forgotten that those who patronise the long distance train services are in general rather exacting persons as regards comfort, and are moreover prepared to pay more to get it. The cost of a first class ticket plus the special supplement for the long distant train is only justified if the traveller who pays it gets not only faster transport but a corresponding standard of comfort during the journey.

On railway vehicles, the traveller has far and away more room than in a motor vehicle or aeroplane. On the other hand, journey times by plane, particularly over long distances, are much shorter. In general, motorcars cannot beat the fast railcars over long runs, particularly if safety is taken into account. Under these circumstances, the increased comfort offered by the railway is a decisive factor, and together with the greater safety of the run, and the fact that the timetables will be respected at all seasons of the year, in spite of atmospheric conditions, the state of the line and the time of day, will bring back a great part of the public to the railway.

Very thorough comparative studies of the series 08 triple railcar and the articulated day service rakes whose interior arrangement is much more costly, have shown that the additional cost for the more comfortable interior arrangement are insignificant; in the economic estimate, they represent the receipts from one or two passengers. All these considerations show that the comfort which passengers are offered in the fast railcars is not only justified in itself, but is essential from the competitive point of view.

(To be continued.)

[656 .215 & 656. 25]

The influence of railway lighting on the visibility of signals,

by Manfred TOLKSDORF.

(*Signal und Draht*, No. 5, May 1956.)

Introduction.

The main purpose of our signals is to enable the engine driver to proceed in safety. Apart from attending to the engine, he has the duty, during the trip, to observe the line ahead with its signs and level crossings, the train itself, and the signals. The driver must therefore be able to recognize the signals, also at night, clearly and in good time without any diminution in the perceiving capacity, and without suffering fatigue. It is therefore necessary to adapt the intrinsic brightness of the signal to that of its surrounds in such a way that the driver is not impeded in his responsible duty. In particular, the lighting must be free from glare.

In the following, it is intended to discuss these interrelations, first of all, on a physical basis, reference being made to the work of Dr. GROSSKURTH (1).

Explanation of technical terms.

1. *Intrinsic brightness :*

An area becomes visible either by emitting light rays of its own, or by reflecting light received from an extraneous source. A source of light has a " brightness " expressed in " Stilb " (*sb*), and calculated from the ratio of the intensity (J) of the source of light in the direction of the eye (measured in Candela = *cd*), and the area seen by the eye, measured in cm² (cf. fig. 1) :

$$B = \frac{J}{f} \left[1\ sb = \frac{1\ cd}{1\ \text{cm}^2} \right]$$

Since 1938, the " Hefner Candle " (HK) has been replaced by the " *Candela* " (*cd*) as the unit of light intensity, 1 HK being equal to 1.16 *cd.*

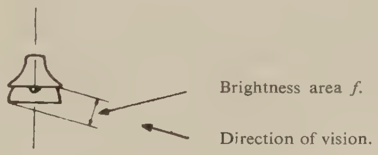


Fig. 1. — Brightness and luminous area in the direction of vision.

Physically, the light intensity J is 1/60th of the intensity of a platinum block with a surface of 1 cm² at solidification temperature.

2. *Glare :*

So far, there is no generally accepted formula for the quantification of the glare effect. The problem has been investigated, and the combination of the different influences has been expressed as a ,, glare factor ". But the glare factor thus determined can only express a general impression of the glare effect. According to one publication the glare factor is calculated as follows (2) :

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(1) Karl GROSSKURTH Ph. D., " Die Tragweite von Lichtzeichen bei Tage und bei Nacht " (Sighting distance of light signals by day and by night), *Signal und Draht*, No. 10, 1954.

$$f = \frac{B_{Li}^2 \cdot \omega}{B_U^{0.6} \cdot \sin^2 \alpha}$$

where :

B_{Li} = brightness of the luminous source;

B_U = brightness of the surrounds;

ω = size of the luminous area at the lighting units, (measured in solid angle units);

α = angle between the line of vision, and the direction from the eye to the source of light.

The effect of the different factors will be discussed later.

3. *Solid angle :*

By " solid angle 1 " is meant that cone which cuts out a surface of 1 m² from a sphere of 1 m radius.

The total solid angle of this sphere is equal to its surface, viz. $4\pi = 12.57$.

The normal field of view of the eye is reckoned to correspond to a solid angle of 5.

4. *Brightness of surround :*

" Brightness of surround " is the luminous density of the area surrounding the luminous source. This area may reflect light, or may be dark. With reflecting objects, the degree of reflection must be taken into account. This is that part of an incident luminous flux which is reflected by the area. The brightness of an area thus illuminated is the product of light intensity (E) and the degree of reflection (ς).

If the intensity of light is expressed in Lux, the brightness of luminous density is expressed in " Apostilb " (*asb*).

Visibility of signals, sighting distance, line-side lighting.

In sighting the signals and the line ahead, by day and by night, the driver's view may be impeded by glare and by areas of relatively great brightness. The influence of sun irradiation can only be mitigated by structural means, especially by the mounting of sun shields.

At night, the driver is faced with a dark surround. The eye is adapted to it, i.e. the pupil is wide open. This is known as the ,, dark-adaptation " of the eye. The fibres which absorb the light and are particularly sensitive to it, are concentrated near the edge of the retina (3). The luminous density of the field of view is less than 0.01 *asb*. If the eye perceives luminous sources of low brightness, e.g. an illuminated window of a house, the eye can easily cope with the task. In this case, however, it is not so much the low brightness itself which enables the driver to see the light without effort or disturbance, but rather the brightness contrast which is small in this case. Good vision, i.e. effortless vision, is largely determined by the contrast between bright and dark within the range of view. Agreeable perception by the eye is possible with brightness contrasts varying between 1 : 20 and 1 : 100 according to the size of the luminous area. It is therefore necessary to eliminate points of high brightness within view. In this connection, it must be kept in mind that the line of vision is normally horizontal.

The magnitude which these brightness contrasts can assume may be illustrated by the following example : the light emitted by the flame of a match has an approximate brightness of :

$$0.7\ sb = 0.7 \cdot 10^4 \cdot \pi = 22\,000\ asb.$$

The night sky has a brightness of about 0.2 *asb*. If a match is struck in a dark room, it has a glaring effect. The brightness contrast between the dark night sky and the flame of the match is thus 0.2 : 22 000 *asb*, or 1 in 110 000. This contrast is so great that the eye is unable to adapt itself simultaneously to both sources of light.

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(2) Dortor-Engineer E.v.d. Trappen : " Das Problem der Strassen- und Verkehrsbeleuchtung " (The problem of street and traffic lighting), *Strasse und Autobahn*, No. 8, 1951.

(3) " Adaptation des Auges " (Adaptation of the eye) by Professor Arndt, Ph. D., in *Handbuch der Lichttechnik* by Rudolf Sewig, p. 566.

A very strong glare effect is experienced where the source of light is surrounded by dark zones or where brightly lit areas are within the field of view at night. This glare effect is due to a local " overload " on the retina known as **absolute glare.**

If, in the presence of absolute glare, the eyes are closed after having " fixed " the glaring light, the picture persists for a time. At this point, the vision capacity is reduced for a time even if the cause of the glare has ceased to be effective. The same may also be the case if only the object has been fixed whilst the source of the glare is perceived outside the centre of the retina.

A similar case occurs if the driving cab is lit up by the opening of the firebox, or if the instrument lighting is poorly screened. If the eye looks straight into the glow of the firebox, it requires a certain time to re-adapt itself to the dark surround. The eye is slower in adapting itself from bright to dark than from dark to bright. During the time of adaptation, the perceiving capacity is empeded, and the driver has difficulty in observing the signals and the line ahead.

The white lights of line-side or station lighting emerge abruptly from the dark and form a very strong and unpleasant brightness contrast against the dark background of the night sky. To obtain good and agreeable visual perception, it is necessary either to increase the brightness of the surround as well so that the brightness contrast does not become unduly great, or to reduce the brightness of the lights by screening, e.g. by means of built-in fittings. In that case, the effect of the light on the eye is not quite so disturbing.

If the vehicle approaches a station equipped with intensive platform lighting which has a high brightness, and if large luminous areas are visible, the driver is exposed to the glare effect as his eyes are unable to adapt themselves to the great brightness contrasts in the field of view. This phenomenon is known as **relative glare.** The eye is adapted to the dark surround and the superimposed, excessively bright localized sources of light reduce the sharpness of vision in respect of the surround, since too much light can enter the wide open pupil.

The glare effect is noticed the more strongly, the higher the brightness and the larger the area of the source of glare. The more closely the picture of the source of glare is situated, in the eye, to that of the object which it is desired to see, the more disturbing is the glare effect. This would be the case if the platform lights would be situated directly in the line of vision of the signal to be perceived (fig. 2).

The disturbing effect is greatest if the source of the glare is close to the centre line of the eye. Glaring light perceived by the peripheral parts of the eye is less disturbing.

After a while, the eye adapts itself to the brighter surrounds. A greater vision effort is required because of the transition from dark-adaptation to bright-adaptation. For this purpose, a certain time is required, due to the retinal persistence, until the sensation has ceased. This adaptation of the eye to the new brighter surrounds has the result that the driver is no longer able to perceive clearly sources of light of lower brightness and, thus, lower intensity, such as signals, because the volume of light emitted from these sources and reaching the eye is inadequate to be properly perceived. The bright sources of light radiate over the whole adjacent area and illuminate it as well.

Once the driver has passed the too brightly illuminated station, his eyes are again required to make an effort as they must now re-adapt themselves to the dark surrounds. On long trips with many level crossings and stations, and with many sources of light in view on streets running parallel to the railway, his eyes are subjected to great strain. Such frequent readaptations can, as already mentioned, cause fatigue and a feeling of discomfort.

With all deep-level lighting installations, the slow adaptation of the retinal system must be taken into account. Similarly, the shifting of the sensation of brightness towards the short-wave side of the spectrum must be taken into account.

With twilight and night vision, i.e. when the eye is adapted to dark, the sensitivity of the eye for reddish and yellow light is reduced, and that for short-wave light (green and blueish light) enhanced (4).

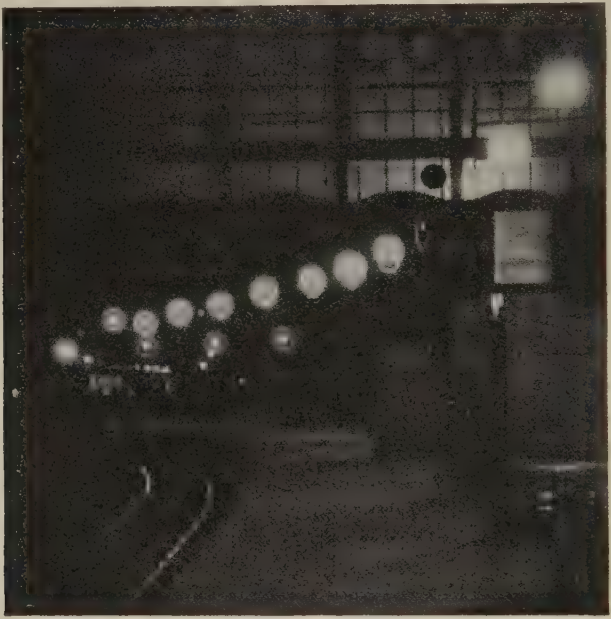

Fig. 2. — Visibility of signals impaired by unscreened lamps.

Using the formula for the glare factor already referred to, the relationship of the different factors may now be discussed. The formula was :

$$f = \frac{B_{Li}^{2} \cdot \omega}{B_U^{0.6} \cdot \sin^2 \alpha}$$

As already mentioned, this term merely gives a general impression of the glare effect. It applies to luminous sources of relatively small size, and to $\alpha \neq 0$.

The brightness of the luminous source, B_{Li}, plays a decisive part in determining the glare as the values are generally high and as they, moreover, appear to the second power.

The further away the light is from the human eye, the smaller is the solid angle ω, and the smaller the glare effect (fig. 3).

The notion of the solid angle has been introduced in order to be independent of the actual distance in determining the glare factor. By reducing the visible luminous area, the glare factor, and thus the glare effect, can be reduced.

The brightness of the surround B_U, is very small, and the dark night sky against which the sources of light are always seen, remains at the low brightness of 0.2 *asb.*

If the lighting intensity around the

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(4) " Handlung fûr Beleuchtung " (Lighting Manual) by Professor Robert SPIESER, p. 13

sources of light is increased (which is admittedly expensive), the immediate surround can be brightened, the luminous density of the wider surrounds increased, and the glare factor thus be reduced. But the value B_U enters the formula only to the 0.6th power.

The angle α between the line of vision and the direction of the source of light is the greater, the higher the sources of light are mounted. In consequence, $\sin \alpha$ and $\sin^2 \alpha$ also become greater. High suspension thus reduces the glare factor through enlarging the interference angle α (fig. 4).

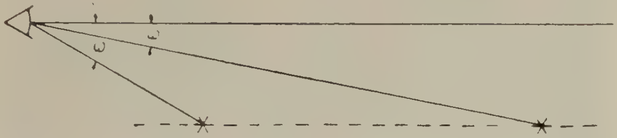

Fig. 3. — Influence of the distance of luminous sources on the glare factor.

In this connection, it is noteworthy that a movement of the source of light from the horizontal line of vision towards right or left has a less disturbing effect than a position in the direct line of vision, or below it. The effect is least disturbing if the source of light, as already mentioned, lies above the horizontal line of vision as the lower retina of the eye is less sensitive.

In America, many tests have been made with a great number of persons in order to find out at what stage the glare effect is felt, and when no glare effect is experienced. On the basis of two independent surveys (by Holloday and Luckiesh) which led to approximately the same results, a graph has been plotted (fig. 5), showing the relationship between the brightness of the luminous source and the solid angle ω for different degrees of brightness of the surrounds (5).

The abscissa shows the solid angle, expressed as the percentage of the size of the source of light in the total size of the field of view. Above the curves representing the brightness of the surrounds (B_U) is the zone of glare. The limit curves were plotted on the basis of the subjective opinions expressed by the persons undergoing the tests, the position of the curves being determined by the points at which 50 per cent of the persons stated that they were disturbed by the glare, and 50 per cent that they were not.

The diagram shows that, e.g. with a very high brightness of the source of light and a low brichtness of the surrounds, the glare effect is experienced even with a small solid angle ω (i.e. over a long distance) (— — — — on the diagram). With the same brightness of the luminous source but brighter surrounds, however, the glare effect is only felt at a larger angle ω (—.—.—.— on the diagram). Best conditions are obtained if B_{Li} is not too strong, whilst

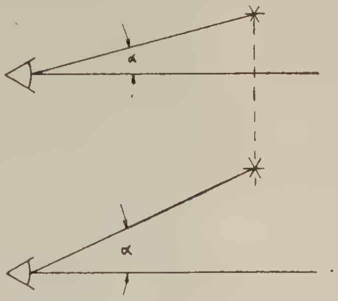

Fig. 4. — Influence of the height of luminous sources on the glare factor.

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(5) " Illuminating Engineering ", 1952, p. 198.

B_U has a comparatively high value. In that case, ω may be large (corresponding to a shorter distance) without a disturbing effect on the part of the source of light (—..—..—..— on the diagram).

Under such conditions, the driver is able to recognize the signals reliably and clearly without great effort. He can observe the line ahead and ascertain that there are no obstacles in the way. During shunting operations, the various types of shunt signals displaying a white light are well visible, and the hand lamp signals given by the shunters can be reliably perceived.

What has been said earlier on about station lighting equally applies to the lighting of marshalling yards (figs. 6 and 6*a*).

Here, the lighting is usually provided by built-in fittings, or is suspended at great height so that there is no disturbing effect on the eye. Difficulties can be experienced during rain when the light of a strong source of light is reflected by puddles of water, by steel sleepers, or by the rails themselves. In that case, the luminous rays reach the eye from below and may cause a glare effect as the reflection of the source of light is in direct view. As already mentioned, the zones at the upper retina are the most sensitive ones. This type of glare is known as "**reflex glare**" (according to Professor Dr. SCHOBER).

An unpleasant reflex glare can also be experienced if the light of platform lighting is reflected on a wet platform (a case which occurs mainly if the light is not correctly adjusted). If the screened lighting units, carrying a number of bulbs, have a high brightness, the glare will be all the stronger.

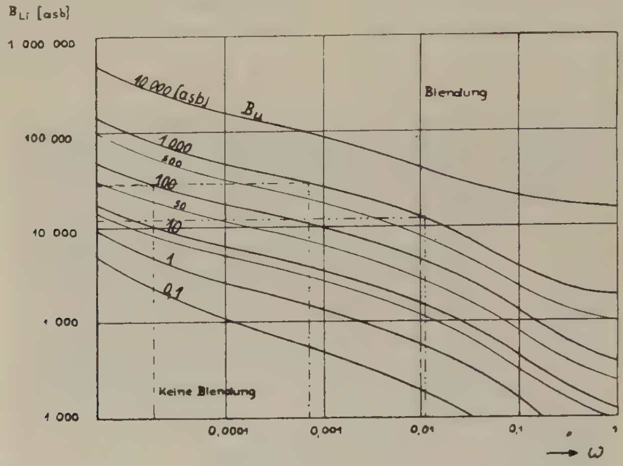


Fig. 5. — Subjective glare effect as a function of the brightness of the luminous source (B_{Li}) and of the solid angle ω, for different degrees of brightness of the surrounds (B_U).

N. B. — Blendung = glare. — Keine Blendung = no glare.

When planning new lighting installations for station platforms, it is advisable to use fluorescent lighting which has a number of advantages from a safety and economy point of view.

Compared with the incandescent bulb, the fluorescent lamp has a far lower brightness (0.4 to 0.6 *sb*, compared with 10 to 40 *sb* for a frosted bulb) so that a reflection has a less disturbing effect.

With a length of 120 cm and a diameter of 3.8 cm, fluorescent lamps have a large luminous area. If they are arranged in the longitudinal direction parallel to the track, the platform edge is well lit whilst the driver, if the lights are suitably screened, can only see a narrow strip of light so that the glare effect is considerably reduced (fig. 7).

He is well able to recognize the signals behind the station since the fluorescent lamps combine a low brightness with a uniform lighting effect.

Diffusers have also been used in order to obtain a further reduction in luminous density. With lighting units of the built-in type, it is possible to obtain an installation which must be regarded as glare-free.

Apart from fluorescent lighting units,

Fig. 6. — Luminous densities of the source of light and of the surrounds are not adapted to each other. The shunt signals can only be recognized with difficulty.

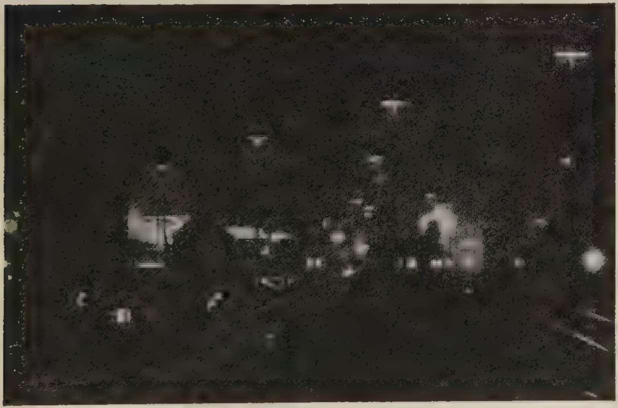


Fig. 6*a*. — The brightness of the shunt signal is adapted to the brighter surrounds. The signals are well recognizable.

there are also other gaseous vapour discharge lamps such as the sodium vapour lamp and the mercury vapour lamp. Economically speaking, the gaseous vapour discharge lamps are cheaper than the incandescent lamps, though their first cost is higher. But, as the current consumption is only about one-third of the consumption of incandescent lamps, they are more economic in the long run. The light yield is the same with all types. For outdoor use on railways, the only gaseous vapour discharge lamp that can be used is the fluorescent lamp as the other two types tend to affect the colour of the surroundings so that the colour of the signals cannot be reliably recognized.

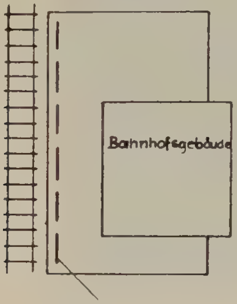


Fig. 7. — Arrangement of fluorescent lighting units along a platform.

N. B. — Leuchten = fluorescent lamps. — Bahnhofsgebäude = station building.

Summary.

The visibility of signals is greatly influenced by the lighting of the surrounds. The most favourable conditions are obtained in the following circumstances :

(1) if the **lighting is uniform,** in terms of time and place;

(2) if the **lighting intensity** is such as to permit the effortless and continuous perception of all possible details within the field of view;

(3) if the **colour shade of the light** is such as to show the illuminated field in a pleasant and natural way;

(4) if the **shade effect** is such that all details of shapes and areas are clearly visible;

(5) if the **luminous density is below** the glare limit;

(6) if the **brightness contrasts** within the field of view are moderate so that the clarity of vision in the centre of the field of view is not impaired.

When acquiring new lighting installations on the railways, more attention should therefore be paid to the visibility of signals.

[625 .25]

The disc brake.

An examination and discussion of the use of frictional materials, with braking forces removed from the wheel rims.

(*Diesel Railway Traction*, September, 1956.)

Once having started a train the most important thing is to be able to stop it. But as with starting and acceleration problems, so the stopping and retardation of trains is governed by the conditions between wheel and rail as they are at the time of each particular stop. No practical means has yet been perfected of applying retardation independent of wheel-and-rail conditions, and a principal problem is to have available always the maximum braking power which the instantaneous adhesion conditions allow.

Friction variables.

Assistance in this direction can be given by reducing the other variables concerned in the stopping of trains, one of the most important of which is the friction between the brake shoe and the wheel. This can, and probably usually does, vary considerably during the course of a stop, and not only affects the actual stopping distance but also prevents anything like exact predetermination of stopping distance which will be of use for everyday service. Indeed, improved consistency of brake performance is more needed today than shorter stopping distances from high speeds for it affects every train in operation — freight and passenger.

Lengthy researches in Germany, for example, have shown the friction coefficient to vary from less than 0.1 to 0.25 during the course of a stop from 60 m.p.h. with ordinary iron brake blocks applied to the treads of steel wheels, and without anything like a straight-line law being followed, as may be seen from figure 1, which gives the spread of the results obtained. Frictional resistance of a cast iron brake block increases to some extent when increased pressure is applied, though not in strict proportion to the pressure; velocity of rubbing also changes the resistance, which is highest at low speed. Heat in the block, and the rate at which heat is being generated while making a stop, are also important factors particularly with high speed stops.

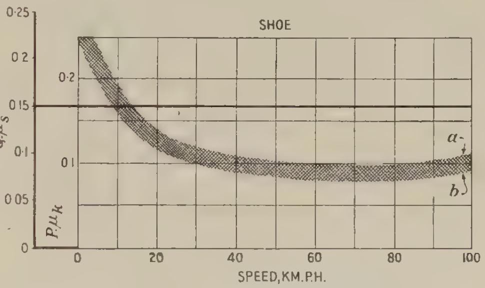


Fig. 1. — Friction of cast-iron blocks on steel tyres; note great variation.

From time to time means have been tried to overcome these factors and give not only improved braking efficiency but also a more even and more controlled efficiency under the most variable conditions. These last points are of increasing importance today, for it is not only the stopping distances of the fastest trains which it is sought to reduce, but also the stopping distances of *all* trains under the full range of wheel-and-rail conditions. Such means invariably involve a change in material from the normal cast iron on steel; and with the exception of the double-block double-material N-R brakes tried at one time on French railcars, and composition rim blocks applied on some electric trains, they have also invariably resulted in the elimination of the wheel rim block and its rigging. That is, in seeking to gain greater control of one of the two principal frictional problems, the sponsors of such means have at the same time always tried to improve the mechanical efficiency of the brake gear, not only in good condition but after repeated applications and the wear of components. The usual brake gear, though accepted as simple because of one hundred years of convention, considerably reduces the efficiency which can be counted on when calculating stopping distances and arranging the relative positions of home and distant signals; and its comparatively low efficiency is anything but constant.

With the beginning of intense development of railcars and the introduction of high-speed trains 20 to 25 years ago the need for something different in stopping mechanism was seen to be required. The lines followed were to reduce the braking pressure substantially by using a material with a high coefficient of friction; and, secondly, to use a material which additionally had a much more constant coefficient of friction than cast iron on steel as represented by brake blocks on steel tyres.

Frictional materials.

The immediate advantages of such a material are indicated in figure 2, wherein the coefficient of friction between lining and steel is seen to be not only much higher than with cast iron on steel but also to vary much less. Just as important, the variation is almost according to a straight-line law from high speeds down to about 15 m.p.h. (with wheel sizes of 35 to 40 in. diameter) so that brake performance becomes much more predictable.

At first numerous attempts were made to adapt drum brakes, usually with internal-expanding shoes but occasionally with outside shoes. Though giving some success in lightweight railcars these arrangements did not have good heat-dissipating qualities, and there was frequent distortion of the drums. Moreover, for anything but light axle loads they involved a fairly heavy dead weight, and some other avenue of development was obviously necessary.

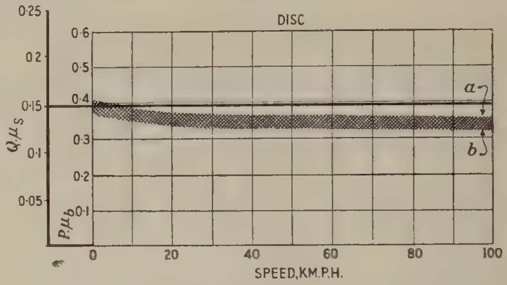


Fig. 2. — Friction of frictional linings on steel tyres; note constant coefficient over normal braking range.

This came in the form of the disc brake. With this type there is greater latitude in design both structurally and in regard to the function as a train retarder; and as far as modern electric multiple-unit stock, Diesel railcars and Diesel trains are concerned it seems to solve most of the problems in super-speed trains, in light railbuses and in multiple-unit suburban trains.

Types of application.

The first practical applications were almost coincident, to Diesel trains and electric multiple-unit trains on the Netherlands Railways and to 410 B.H.P. Diesel railcars on the then Reichsbahn in the year 1934, the last-named following drum-brake installations on the original *Flying Hamburger*. These early designs were due to the late A. Fuhrman of the Bergische Stahl-Industrie, of Remscheid; and B. S. I. has continued manufacture and development to this day, with an increasing number of applications over the last few years. The principal applications of disc brakes, in Germany, Holland, Italy, Argentina, and the U. S. A., have been to Diesel railcars and electric trains, both express and suburban; but physically they are applicable also to ordinary passenger coaches, and have been so used, for example, in the once well-known Henschel-Wegmann high-speed steam-hauled train of prewar years, and also in modern American Pullmans and ordinary coaches.

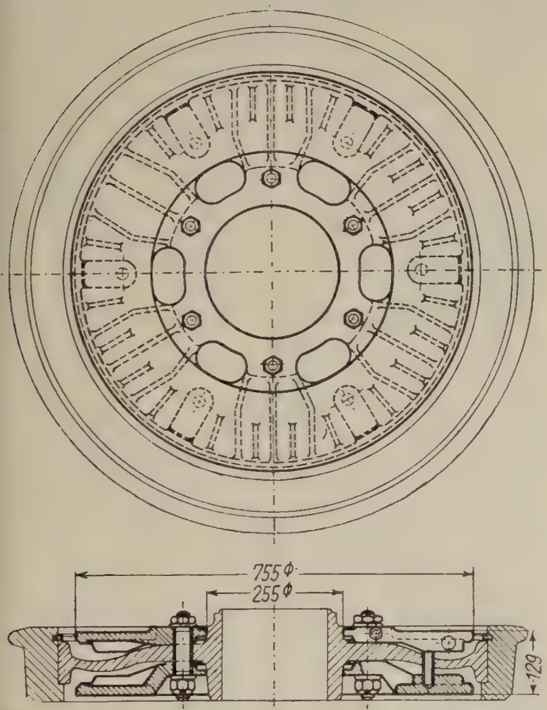


Fig. 3. — General arrangement of the two braking discs applied to the wheel itself.

In its modern form the B. S. I. disc brake has two variations : first, a single disc mounted on the axle, a pattern used in the 600 Uerdingen Diesel railbuses on the German Federal Railway and in other applications; secondly, a double disc attached to each wheel of gear-driven wheel-and-axle sets in high-speed or heavy railcars and railcar-trains. The type used is governed by the weight to be braked and the braking speed and conditions, and also by the constructional details of the vehicle, an axle-mounted disc, for example, not being practicable in conjunction with nose-suspended traction motors, though it is with the usual bevel and bevel-reverse axle gears.

Wheel discs.

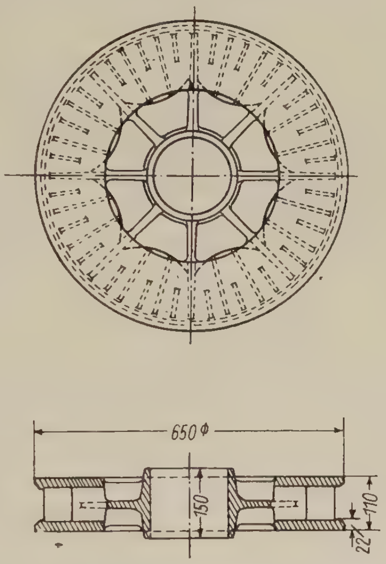


Fig. 4. — General construction of double-faced brake disc of the type mounted on the axle between the wheels.

In figure 3 are shown details of the double disc attached to a wheel centre, and in figure 4 is shown the double-faced single disc as mounted on the centre of an axle. Figure 5 shows one of the possible brake gear assemblies with the wheel discs. In the wheel disc type all the elements are located within the normal contour of the wheel-and-tyre assembly and do not extend beyond the loading gauge at any point. As a result, a comparatively large diameter of disc can be used, up to about 30 in. for a tread diameter of 35 ½ in. The larger the disc diameter, and so the greater the radial distance from the axle centre to which the brake shoes can be taken, then the smaller the necessary force of application through the shoe, and the smaller the specific pressure on the frictional lining. The wear of the material also will be less. Adequate cooling is essential, and for that reason the discs have holes and ribs to induce a flow of air over the whole surface, the ribs running almost radially and acting as a ventilating fan, conducting the cool air which enters the six holes round the wheel boss (see fig. 3) to the periphery, where the air escapes through the annulus between the wheel rim and the brake discs.

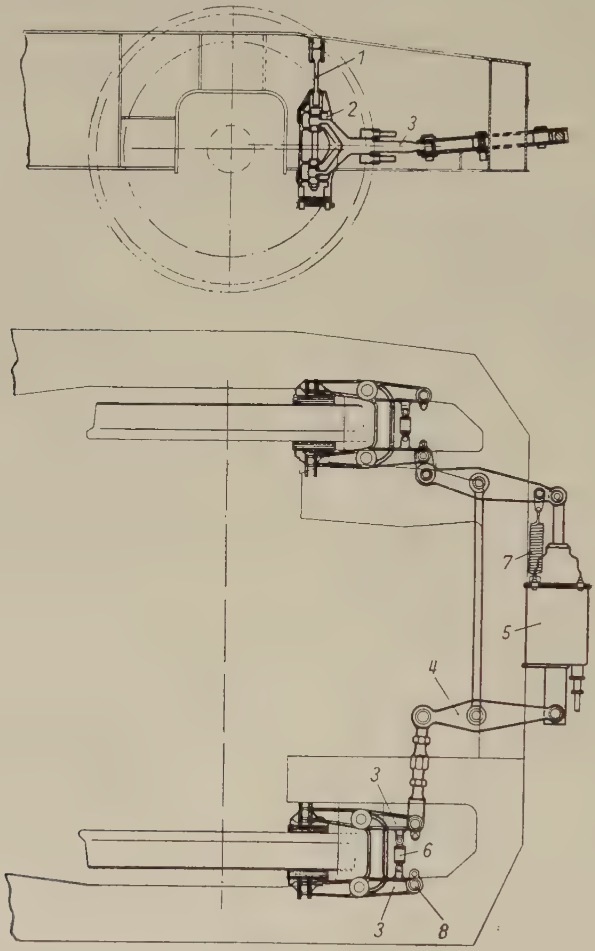


Fig. 5. — Arrangement of brake gear to suit double-faced wheel discs on one wheel-and-axle pair, with one Knorr brake cylinder.

For reasons of assembly the discs on the road wheels are made with the external disc as one piece but with the inner disc in two parts, the two parts being held together by bolts and castellated nuts. The two brake discs are centred on the wheel hub and are tied together by driven bolts, and the facings of the discs and the wheel centre must be machined to close limits. The two discs are further connected by six short tubular struts equally spaced round the discs near the periphery, the purpose of which is to ensure that the braking forces can in no way strain the wheel centre. The outer surfaces of the two discs serve as the rubbing surfaces of the brake linings. On a driving bogie, particularly if engine and transmission are mounted on it, the practice is to have the double disc on each wheel, with a shoe against each surface; but with other bogies, where the axle load may be lighter, only one wheel on each axle has the double disc and its two shoes.

Axle discs.

With carrying bogies, or with axles which have no cumbrous driving mechanism, the brake disc at or near the centre of the axle is an obvious solution. The disc is lighter in weight and less expensive than the wheel discs, and the ventilation also is better. On the other hand the possible diameter of the disc for any given wheel diameter is less, due to rail clearance requirements; and with a 35 ½ in. wheel, allowing for a wear of 1 in. on tread and a rail clearance of 5 $^1/_8$ in., the maximum disc diameter will be about 23 in. These centre discs are in one piece, as shown in figure 4, but of course have the two opposing sets of shoes gripping the disc on both sides. A seat on the axle has to be provided, and this must be greater in diameter than the wheel seat so that, if necessary, the brake disc can be pulled off over the wheel seat. No key is needed in the brake disc seat, the frictional pressure of the pressing-on fit being sufficient to prevent movement. Here, again, there are radial ribs acting as ventilating fans to carry off the air which enters the space round the wheel boss; and, like the ribs of the wheel discs, they must be equally effective in either direction of travel. Both types of discs are made from quenched and tempered electrically-cast steel of 38 to 42 tons per sq. in. ultimate tensile strength, a type of work for which the B. S. I. plant at Remscheid is famous. More recently, two discs mounted on one axle have been applied, to the 150 Uerdingen twin-engine 300-B.H.P. railbuses recently built for the German Federal Railway.

As far as the axle disc is concerned, it should practically never be necessary to pull the disc off the axle, for not only is the rate of wear on the side surfaces of the disc extremely small but it is possible to true up the disc in situ. Yet to get over all objections on this score a two-piece axle disc has been evolved in which the disc hub remains permanently on the axle.

Brake equipment.

The B. S. I. brake can, of course, be applied by any form of compressed air equipment, the Knorr being the usual pattern in Europe, and the Knorr Bremse A. G. has evolved special cylinders and equipment to suit it. There are no difficulties of brake application in multiple-unit; and actually disc-braked vehicles can be run in the same train as normally-braked stock. The rigging is essentially light and simple; indeed, it is one of the prime advantages of this class of frictional brake that throughout the life the rigging operates with short and constant travel, with practically no lost motion, and with maintained high mechanical efficiency.

In the wheel disc type as shown in figure 5, one cylinder per wheel-and-axle assembly is needed, and is mounted transversely on the bogie headstock or other convenient part. Each shoe assembly has a suspension link 1, taking the weight of the shoe and carrier and of part of the tongs, and also transferring the vertical forces arising from the braking action to the bogie or vehicle frame structure. There is a holding fixture 2 and the brake tongs 3, the tongs comprising cast steel or welded steel levers and the bridge piece between; the pin and bushing 8 form the fulcrum point. Between the tongs and the brake cylinder 5 is the rigging 4 and the return spring 7; and to regulate the gap between the frictional lining and the disc, whatever the lining wear, is an automatic spring-bow type of adjuster 6, developed by Teves. The distance on German Federal Railway applications is 1 mm, and the action of this regulator is positive and sensitive enough for all the disc and lining assemblies on a complete railcar or train to have the same gap within close limits. Incorporated in the brake cylinder piston rod is a further device, evolved by Knorr, to maintain constant brake piston stroke and braking effect. This is required only on fast or heavy railcars with great braking efforts and where the maintenance of the highest standard of braking efficiency is vital. In light and low speed railcars the automatic adjuster 6 between the tongs is sufficient.

With the axle type of disc the rigging is even simpler and the parts fewer. There are no brake rods here, see figure 6, and the air brake piston rod acts directly on the tongs.

Shape and position of shoes.

The general shape and location of the actual friction-lined shoes are indicated in figures 5 and 6; but a detail view is given in figure 7. Referring to that illustration, 1 is the ribbed holding or backing piece; 2 are the two intermediate pieces; 3 are the two friction linings riveted to 2. There is a fixed locking piece 4 and a removable fastening cap 6. The kidney-shaped piece 1 is of high-grade cast iron and has a continuous dovetail-shaped longitudinal groove into which the intermediate pieces 2 are inserted. The other side of piece 1, that is the side away from the brake disc, has four integral brackets into which bushings are pressed to take the shackle bolts of the operating mechanism (see fig. 6). The actual points of attachment of the shackle are most important in order to gain a uniform rate of wear over the friction lining, for the rubbing speed of the disc over the lining is not uniform. As a rule, the centre of attachment of the shackle bolts lies a few mm nearer the axle centre than does the centre of gravity of the brake lining. On a practical basis, as the frictional lining wears and must be replaced from time to time, a railway using this type of brake normally determines on a standard pattern and size of friction lining which will cover a variety of disc diameters, and varies the points of attachment of the shackle bolts.

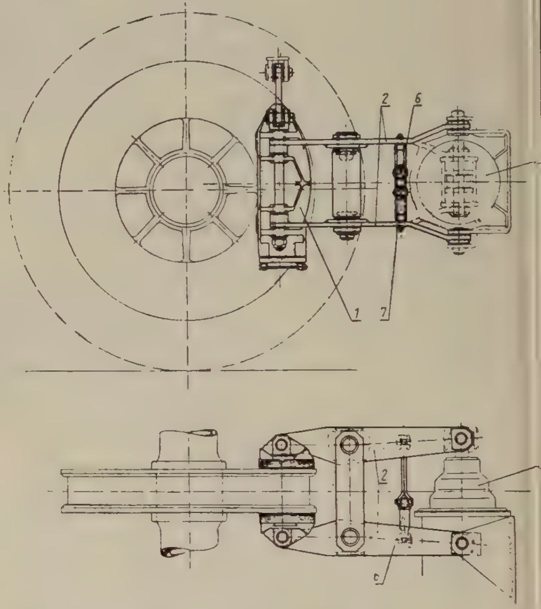


Fig. 6. — Layout showing simple brake gear to apply two shoes to a single axle-mounted disc of the B. S. I. brake.

Friction lining specifications.

The potentialities of any brake with frictional linings as opposed to cast iron blocks on steel wheels are great enough to warrant considerable attention being paid to the frictional material, and B. S. I. has spent many years in developing a material which would meet all requirements, and which could be further developed to suit the ever-increasing speeds and weights. This work, together with the investigation of other braking problems, has been helped greatly by a comprehensive test stand erected at Remscheid. In collaboration with the German Federal Railway and the makers of frictional materials a detailed specification has been drawn up, and this is adhered to most strictly.

After many tests and much running experience with materials such as a mixture of asbestos fibre with metal chips and a mineral filling compound, eventually a material of Buna rubber and steel shavings was adopted; and the improvement this gave, coupled with increased experience of the rigging and general layout, has led to the use of only two shoes per disc, whereas in numerous prewar installations four shoes per disc were fitted.

In regard to the specification for the frictional linings themselves, one of the vital points is the thickness of the lining (piece 3 in fig. 7); tolerance limit for this is only 0.15 mm. The fabric, binding agents and other materials have to be evenly distributed throughout the lining piece without nests or blisters, and samples are cut in longitudinal and transverse directions to verify this.

Under normal maximum service brake applications the lining has to sustain a surface pressure up to 86 lb. per sq. in. in conjunction with a rubbing speed of 76 ft. per sec, or 108 ft. per sec in a stop from high speed. Under these conditions the coefficient of friction between lining and steel rubbing surface must remain within the limits of 0.32 to 0.38 throughout the retardation period, though at rubbing velocities below 10 ft. per sec values up to 0.42 are allowed. On the German Federal Railway two classes of lining are used. Class II is in accordance with the above figures; Class I is used only for vehicles which do not run faster than 56 m.p.h. ad where the brake shoe pressure through the frictional lining does not exceed 15 lb. per sq. in.

Water and ice conditions.

Water absorption in both classes has to be low, the stipulation being that after submersion in water for 24 h the weight change must not exceed 8 %. Further, the frictional value after the soaking must not change by more than 15 %. Brake testing of the frictional linings and assemblies on the Remscheid test plant simulate emergency and full application stops, which may take up to 45 sec per stop; and there are subsequent holding tests to simulate steady braking to a given speed on long down grades, a standard test being for 25 min at a speed equivalent to 37 m.p.h. track speed. Here the total pressure on any block may be in excess of 1 300 lb., but the maximum temperature must not exceed 300° C nor the rate of wear of the frictional material 0.1225 cub. in per HP/h absorbed. Both of the above tests have to be sustained in sequence without any damage, burning or crumbling away of the binding compound. The frictional material now used is capable of withstanding temperatures in excess of 400° C.

With any modification of material there are not only repeated tests as above, but also others to correspond with dry, wet and ice-covered linings, the specification for the last-named calling for 2 mm of ice on both lining and steel disc, that is equivalent to an ice-bound condition. In actual working out on the line the glass-hard layer of ice cracks off immediately on application of the brakes; and compared with a perfectly dry lining and disc the increase in stopping distance from a speed of 75 m.p.h. has not been more than about 16 %, this being with a complete freezing between shoe and disc, a condition which would occur very rarely in practice. With wet frictional shoes, that is after 24 h soaking, the stopping distances from 75 m.p.h. have been about 9 % longer than with perfectly dry linings and discs. But within the last two years linings slightly modified have shown no increase at all in braking distances because of wet shoes. Despite the somewhat increased stopping distances with ice-covered and many wet disc brakes compared with those perfectly dry, the stopping distances of all are measurably less than those effected with cast iron blocks on the wheel rims.

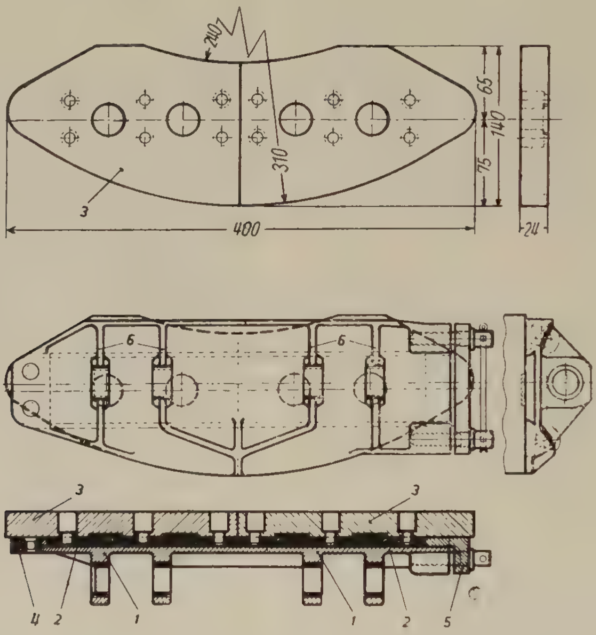


Fig. 7. — Details of brake shoe construction and frictional lining of B. S. I. disc brake as used on Diesel motive power of the German Federal Railway.

Steep-grade tests.

In years gone by interesting tests were made with various Diesel railcars and trains of the old Reichsbahn in high-speed braking and in holding power down long grades, for example on the four miles of 1 in 16-20 of the Höllental line. A 49-ton Diesel car was also run down the 12 miles averaging 1 in 33 between Seefeld and Innsbruck, and the 15 ½ miles averaging 1 in 40 between Langen and Bludenz, on the Austrian Federal Railways. On these tests the car was held to steady speeds of 25 and 31 m.p.h. respectively by the use of the disc brake alone; the braking HP was 28.5 and the maximum temperatures attained by the discs were 210° C and 270° C respectively.

In recent construction the B. S. I. disc brakes have been applied to the VT.08 express and VT.12 inter-urban triple-car Diesel-hydraulic trains of the German Federal Railway. In the VT.08 trains (described in our issue of Marsch, 1954), the normal braking distance from 75 m.p.h. with the disc brakes is 700 yd., equal to an average retardation of 2.85 ft. per sec per sec. From a speed of 62 m.p.h. the braking distance is about 465 yd., whereas the new triple-car single-phase electric trains with cast iron blocks on the wheel treads require a distance of 510 yd. from the same speed, an increase of 10 %. An interesting point of the VT.08 trains is that the construction of the lower part of the body and framing, in which the side skirts and framing are carried right round below the floor (see pages 54 and 55 of our March, 1954, issue), seems to improve the cooling of the discs and largely prevents the whirling up of snow.

Railbus results.

These Diesel trains have the wheel disc brakes; but the four-wheel Uerdingen railbuses, now numbering about 600, have the axle disc brake; and in a total distance of something like 12 000 000 miles they have shown a frictional lining life averaging about 50 000 miles, this covering cars in flat country and cars in mountain areas with grades up to 3 ½ miles of 1 in 30, and both summer and winter conditions. Moreover, this intensive railbus experience has shown an improvement over many of the results on the test plant in that frozen discs and linings, and wet discs, have not given any increase in stopping distance, though in many winter cases the disc assembly has had to plough a rut through snow drifts. Illustrations of one of the latest double-engine 300 B.HP railbuses appeared on pages 377-78 of the December, 1955, issue, and in both the axle discs — in this case two per axle — can be seen in position.

Three further proved advantages of this type of disc brake may be mentioned briefly. First is the reduction in weight. On the German triple-car Diesel trains with two driving and four carrying bogies the brake equipment weight is about 7 250 lb. On the same railway's modern triple-car single-phase electric trains with cast iron blocks on the wheel rims the equivalent weight is 12 200 lb. In both cases the weight of the reservoirs, driver's brake valves and other common equipment in the car bodies is not included.

Secondly, there is the smaller expense of upkeep — in the less work required in frequent adjustments and brake block renewals and in the cost of new brake blocks. Comparative costs of maintenance and renewal of all brake equipment on the triple-car Diesel sets per 100 000 miles are £ 185 for the disc-braked train and £ 730 for the block-braked train, both figures including labour and material, and being converted at D. M. 12 to the £.

Thirdly, there is the quietness of operation, not merely in the application but in the elimination of that infernal rattling and wheezing which so often accompanies the release of ordinary air or vacuum brake rigging, and the avoidance of which noticeably enhances the comfort or railway travel. — B. R.

[**625** .151 (42) & **625** .174 (42)]

Oil circulation point heaters on London Transport lines.

Apparatus using a hot-oil circulation system for applying heat to point tongues and adopted by L.T.E. has given excellent results in severe winter conditions.

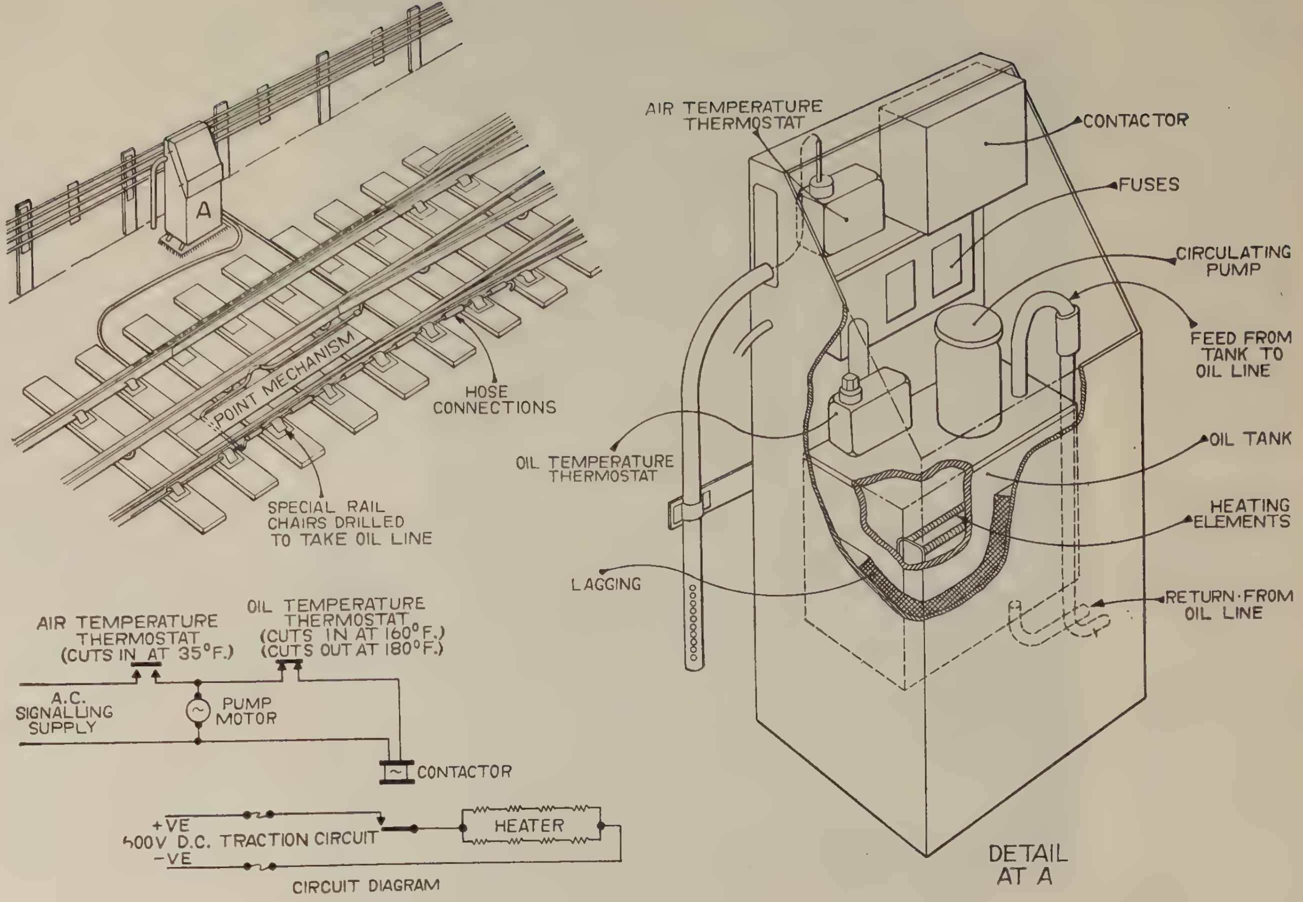
(*The Railway Gazette*, September 21, 1956.)

One of the greatest difficulties confronting railway managements in some parts of the world is to secure maximum freedom from trouble in working the traffic in winter, when snow and ice interfere considerably with the operation of points and other items of equipment along the permanent way. Should the working of points become disturbed it can have far-reaching consequences on train movements and cause much delay, which latter may itself perhaps be additional to that arising from other consequences of the nature of the weather, against which it is not possible to take much effective action. Although bad winter conditions are not met with in Great Britain to the extent that they are in some countries, they can at times be severe enough to give rise to much anxiety to those responsible for traffic working.

Frequently it is necessary to employ considerable numbers of men in keeping points free from obstructions, and if circumstances are such that they cannot be obtained, or are available only in insufficient numbers, delays are inevitable. Various proposals have been made, and some put into effect, for applying heat to point layouts to prevent freezing, usually by attaching electric heater elements to them, which of course necessitates some suitable source of power being available, and on some railways they have been used successfully. On the open sections of London Transport lines, however, such equipment was found not to give entire satisfaction and accordingly it was sought to device some method less liable to breakdown and more economical to operate and maintain, while enabling heat to be distributed evenly over the entire point layout, including its electropneumatic or other form of operating mechanism, to maintain every part of it free from frozen deposits.

Hot oil circulation system.

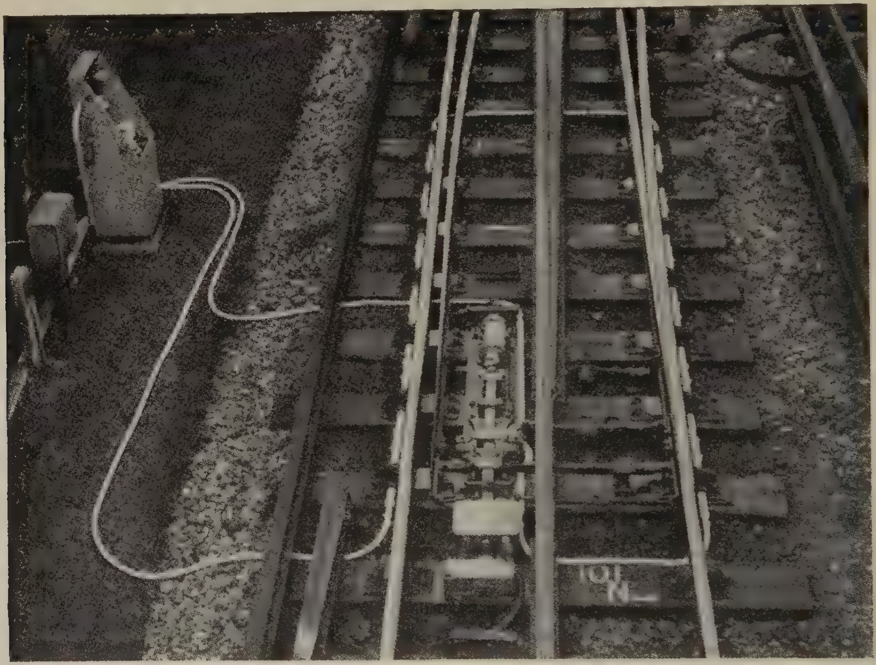
For some time this has been realised in the so-called hot oil circulation equipment here described, the subject of gradual improvement in the light of experience since the first trials were made with it some 12 years ago. In 1942, a patent was applied for by Mr. J. H. Condy, an engineer in the service of the then London Passenger Transport Board, and this was granted to him and the Board under date of December 14, 1943, and No. 557993, the claims, six in number, covering the equipment exactly as present used, save for mechanical details not in themselves related to the principles involved. These are that a reservoir of transformer oil is provided close to the line and connected to pipes forming a closed circulating system passing through longitudinal holes in the bases of the slide chairs and connected by welding to the foundation plate of the point operating mechanism. In the reservoir is an electric immersion heater controlled by two thermostats, one of which is acted on by the temperature of the surrounding air. When this falls to 35° F. the heater becomes connected to the traction current supply and a pump sets the oil in circulation, so that sufficient heat becomes communicated to the chairs, etc., and frozen material cannot form thereon. (The wattage of the heater element is 6 000 but it is underrun at about 4 000.) To economise power the second thermostat disconnects the element when the oil reaches


AIR TEMPERATURE THERMOSTAT
CONTACTOR
FUSES
CIRCULATING PUMP
FEED FROM TANK TO OIL LINE
OIL TANK
HEATING ELEMENTS
RETURN·FROM OIL LINE
OIL TEMPERATURE THERMOSTAT
LAGGING
DETAIL AT A
A
POINT MECHANISM
HOSE CONNECTIONS
SPECIAL RAIL CHAIRS DRILLED TO TAKE OIL LINE
AIR TEMPERATURE THERMOSTAT (CUTS IN AT 35°F.)
OIL TEMPERATURE THERMOSTAT (CUTS IN AT 160°F.) (CUTS OUT AT 180°F.)
A.C. SIGNALLING SUPPLY
PUMP MOTOR
CONTACTOR
+VE
600V D.C. TRACTION CIRCUIT
−VE
HEATER
CIRCUIT DIAGRAM

General layout of apparatus and control circuits used with oil circulation point heaters, L.T.E. lines a temperature of 180° F. and brings it into operation again when it drops to 160°. In this way power is used for only about half the time the apparatus is required to function. Hose connections are used between the chairs, to afford some degree of flexibility there, and also where necessary to avoid short circuiting of the track circuit. Originally there was no piping in the chair bases but the latter were found at times to be porous and therefore not oil proof; it was therefore decided to put piping through the chairs, the hoses joining the nipples thereon.

The oil circulation was in the first installations produced by a thermosyphon action but this was replaced by an impeller, driven by a 100-HP motor and later, in the newest type of apparatus, illustrated on the accompanying drawing and photographs and of which a large number of sets are now in service, by an actual pump of robust design. The design of certain other components has had to be slightly modified in the light of practical experience, as was only to be expected, but the essential principles of the working have not been departed from.

In the first installations the oil bath was placed below ground and connected by solid piping run in troughing to the points, but when it was decided to fit a large number of additional locations a complete self-contained assembly, in which everything was above ground level, was designed by the Siemens & General Electric Railway Signal Co., Ltd., and with this hose connections laid on the ballast have replaced the solid tubing. Arrangements are made for filtering the oil at intervals to clear it of any deposits.



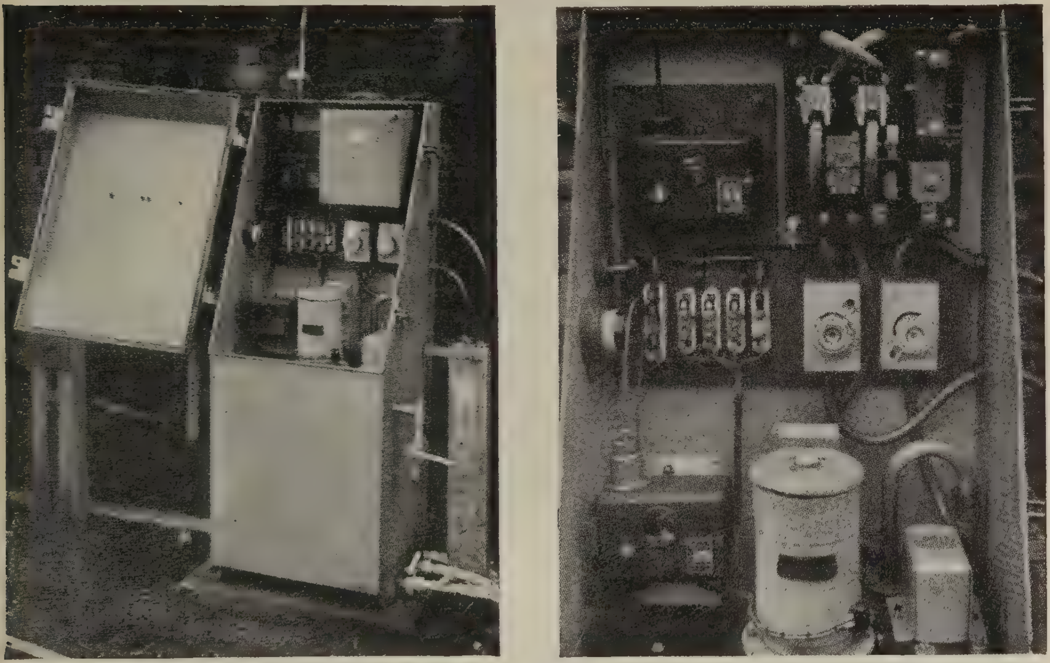
Set of electro-pneumatically operated points fitted with oil circulation heating equipment.

Power supply.

As the power required for the heating is derived from the traction supply it is on occasion necessary to leave the conductor rails on certain lines alive after traffic working hours, when weather conditions necessitate, but at some locations it is possible to take power from siding rails that are normally continuously alive. (Power for the pump motor and the contactor is taken from the A.C. signalling supply.)

Application of the equipment.

The principle followed in applying the equipment is to treat the more important sets of points, giving preference to facing points, and endeavour at the same time to abolish or greatly reduce the amount of overtime or other labour required to keep points free in bad weather. Where for example men must be available in any case and can occupy themselves with such work, should circumstances require it, there is no real advantage in applying heaters, but where the retaining of staff on long hours of duty would be essential the position is very different. A careful survey was made therefore with these facts in mind and a programme agreed upon prescribing the locations where heaters should be applied. Of the total of 1 464 worked points coming under the control of the Signal Engineer, Mr. R. Dell, on the London Transport lines, both in tunnel and in the open, about 600 are now equipped. The apparatus has given great satisfaction and in the periods of severe weather at times approaching blizzard conditions, experienced during the last two years has kept the points working freely.



Apparatus case, showing hose and cable connections; (on right) view showing contactor cover removed, with pump in centre and thermostats on left.

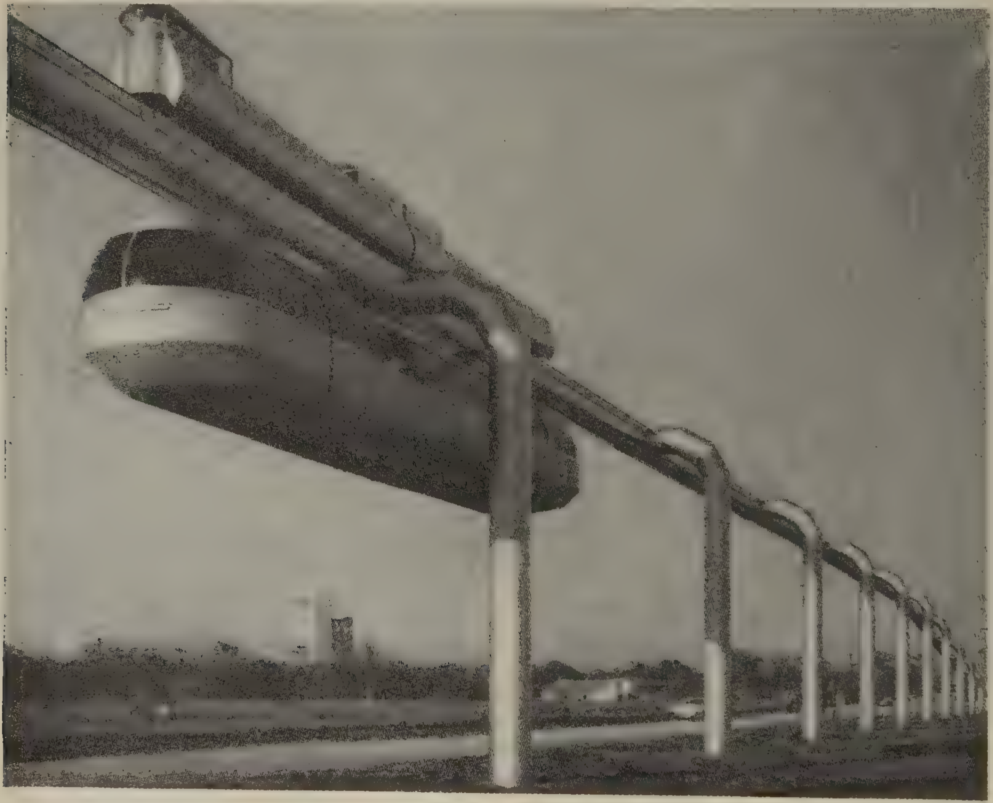
It has, of course, been designed to function with bull-head permanent way, where heavy cast iron chairs are used, and would require to be re-arranged to work with flat-bottom rails, but no doubt this problem could be solved if necessary.

[**625** .3 (73)]

Test of monorail line in Texas.

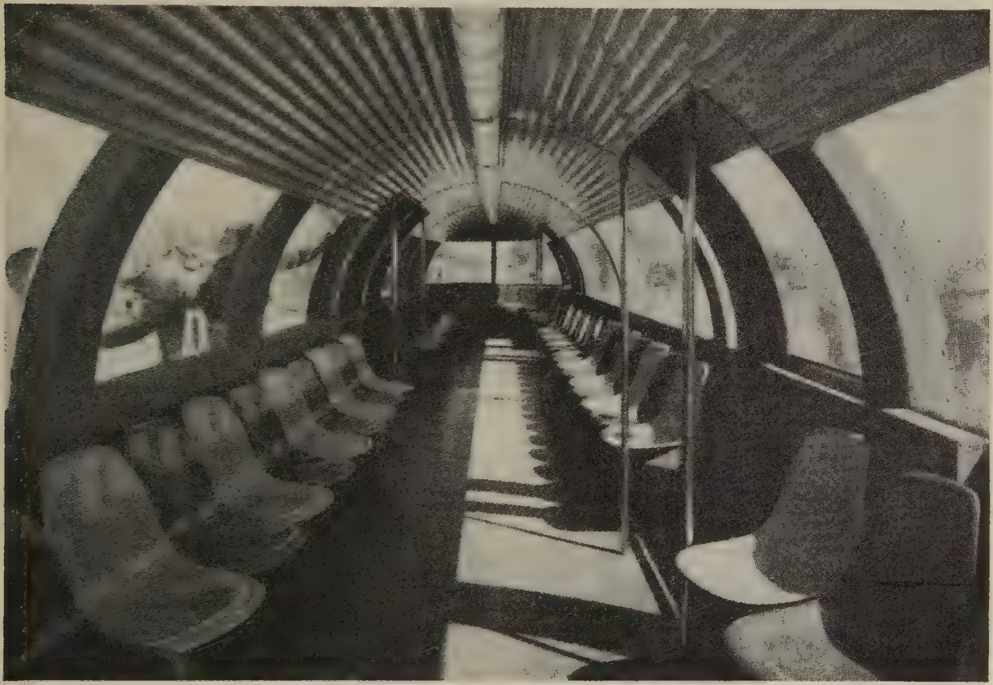
(*The Engineer*, September 21, 1956.)

The accompanying illustrations show an aerial coach which was recently operated as part of a demonstration of a monorail line at Houston, Texas. The 970 ft. long test installation is of the design which Monorail, Incorporated, 4118 Fannin Street, Houston, Texas, plans to fabricate and build, for lease or sale to transit companies or authorities. The aerial coach, which seats sixty passengers, is said to be a radical departure in design and operation. Its construction makes use of what the builders call « concentric suspension » and consists primarily of a series of suspended concentric steel rings braced by an arrangement of longitudinal steel stringers.



Test run of monorail line at Houston, Texas.

The oval-shaped coach is capable of a speed of 100 m.p.h. with its present power — two 305 HP internal combustion petrol engines. However, Diesel or electric motors can be used, and the rails and towers have been designed so that the coach, with suitable power, can travel at a much greater maximum speed. Eighteen 30 ft. high inverted « J »-shaped steel towers with bell bottoms support the rail beam. These cylindrical towers are spaced 55 ft. centre-to-centre. There is an 18 ft. clearance above the ground. One end of the rail slopes down so that the coach can rest on the ground while taking on passengers. The steel-ribbed coach, which weights 26 700 lb., is 54 ft. long, 8 ft. wide, and has an inside height of 7 ft. It is almost completely covered with a skin of reinforced polyester resin. The remaining part of the surface is glazed with a tinted translucent plastic. The coach is equipped with automatic electric brakes and couplings, and carries a 7-ton air conditioning system. The driver-operator, sitting in a dome on top of the coach, is able to see the entire track area. The coach is operated much like an automobile, but uses only two gear shifts instead of four or five. It has eight pneumatic rubber tyres that lock on the rails. On top of the rail is a locking guide rail. If these should be a blow-out, one of the eight auxiliary wheels takes hold.



Interior of monorail demonstration coach.

[656 .25 (73)]

Communications... — in the decade ahead...

Must be vastly expanded to exploit speed of electronic « brains ». Will provide automatic switching for interline car reporting, coast to coast. Will absorb many times existing circuits.

(From *Railway Age Centennial Issue.* 1856-1956).

We have extracted from the Railway Age Centennial Issue the following considerations on the prospects of development of telecommunications during the next ten years.

The giant « brain » being hoisted to a new data processing headquarters is symbolic of the kind of large-scale « digital computer » some dozen railroads in the U. S. and Canada have ordered. It will give management the kind of integrated information it needs at incredibly fast speed—*provided* management also sees to it that its communications network has the speed and capacity to funnel in and distribute the information which its electronic impulses digest, reassemble and grind out. The indispensable preparation to the full use of data processing equipment is expansion and refinement of a railroad's communications system.

The railroads have already entered the era of « automation of intelligence ». They have actively adopted modern business machines to accounting processes, purchases and stores operations and inventory, movement and assignment of freight and passenger cars, payrolls, pay checks, dividend payments and cost accounting, among others. Daily inventory of empty freight cars by type and location, perpetual inventory of stores, and « queuing » of inspection scheduling of locomotives are examples of uses for digital computers already at work.

A coast-to-coast passenger reservation system is being installed by the New York Central, New Haven and Santa Fe. Agent's keysets in 60 cities will be connected to electronic memory storage drums in New York and Chicago which can store reservations for all trains of the three roads for up to seven months. Several other railroads are actively interested in joining the system.

Car reporting.

Printing telegraph will continue to be installed in greater quantities on all railroads. Soon all major railroads in the U. S. and Canada will utilize it for system-wide car reporting systems.

These systems will be tied together as present difficulties — like station code numbers — are overcome. Right now, the Union Pacific, Southern Pacific, Chicago & North Western and Milwaukee are interchanging car reporting information for cars in service between Chicago and the West Coast. By 1966, coast-to-coast car reporting, covering virtually every railroad in the country, will be in service.

Transceivers, a new development, will undoubtedly be utilized to a greater extent. These devices transmit and receive over long distances the information on punch cards.

A number of railroads have automatic dial telephone systems in service; more will install them. The trend to intercity long-distance dialing is strong. (The SP will have intercity dialing on its entire system in about two years, and the UP has started such a project this year.) By providing better telephone service, many roads will experience a decrease in costly letter mail. One railroad's motto is : « Don't write if you can wire; don't wire if you can phone ».

Transmission by wire of written information which is automatically reproduced at the receiving station will have many uses on the railroads. Already the Pennsylvania, for example, is using Intrafax facsimile to issue tickets remotely at offices of large industrial customers and outlying ticket offices. Facsimile may be used for tying yard offices with yardmaster's, retarder and interlocking towers — transmitting switch lists, for example.

To provide more circuits for these expanded uses of communications, the railroads will make use of carrier — which gets more work out of existing line wires — and microwave. Some roads will install twice as much carrier in the next five years as they did in the previous five years.

Several railroads are looking to microwave to supplement or replace pole lines. Microwave, like carrier, is a many-circuit facility. It can handle up to 120 voice channels — each channel capable of handling up to 18 telegraph or printing telegraph circuits. Several possibilities for its use are being considered : one road thinks microwave would provide additional circuits more economically than laying a submarine cable across a bay; Another road would « collect » communications traffic at an on-line terminal and provide microwave transmission to off-line headquarters.

While present-day microwave systems have repeater stations approximately 30 miles apart, a new development — known as « over the horizon » microwave — utilizes larger, more powerful antennas — capable of sending the « radio beam » 200 to 300 miles without repeater stations.

Radio will be « standard equipment » on locomotives, cabooses, in wayside offices and yard offices. It will be available on official automobiles of yardmasters, trainmasters, division superintendents and supervisory personnel in the signal, communications and engineering departments. The lineman will have radio on his track motor car, as will the track supervisor. Track maintenance equipment — like tampers and ballast regulators — will keep in touch by radio. Radio will enable scattered railroad personnel to work, in effect, like those of most other industries do « naturally » — side by side.

By 1966, major yards will be equipped with industrial television to provide for the yardmaster general surveillance and close-up views. Car checking and car inspection by TV will be commonplace. Other uses of TV seem limitless. The Pennsylvania, for example, will use it in a new ticket sales bureau to show clerks and passengers at a number of spots what space is available.

An electronic hot box detector which will detect heat radiated from freight car journal boxes on trains moving at 60 mph is about to be installed on the Rock Island. It will transmit intelligence of hot boxes to points where proper action can be taken immediately.

A line-side photoelectric device which automatically identifies freight cars moving up to 60 mph — by « reading » black and white stripes on their sides — is now in the testing stage. Working with a Teletype machine this unit could « read » the cars of an outbound train and send a checked, last-minute consist to points beyond.

Transistors and printed circuits, now available in a limited number of electronic devices, will become standard components during the next decade for carrier equipment and radios. Use of these two developments will lower maintenance costs because whole units can be pulled out and replaced. Transistors and printed circuits will probably cut the weight of standard railroad radio equipment in half.

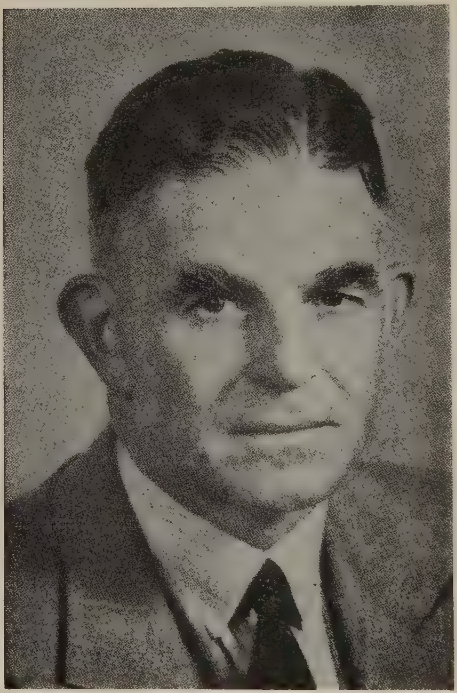
[385 (09 .2]

OBITUARY.

H.D. WARD SMITH,

O.B.E., E.D., A.M.I. Mech. E., M.I. Loco. E.,

Formerly Assistant Chief Mechanical Engineer (Motive Power), South African Railways and Harbours.
Former Member of the Permanent Commission of the International Railway Congress Association.



We regret to record the death on June 14 last, of our former colleague Mr. H. D. Ward Smith, formerly Assistant Chief Mechanical Engineer (Motive Power) of the South African Railways and Harbours.

The following biography of this eminent personality of the South African Railways is an extract from *THE RAILWAY GAZETTE.*

Mr. Ward Smith was born in the Orange Free State on December 21, 1896, and after being educated at public schools at Bloemfontein and East London, was apprenticed with the South African Railways. He enlisted in 1915 with the 1st South African Brigade, and served in Egypt and France until 1918. He returned to South Africa and completed his apprenticeship in 1923, studying also at East London and Pretoria Technical Colleges. In that year Mr. Ward Smith joined the C.M.E. locomotive drawing office, and he thereafter held various appointments until he became Assistant Mechanical Engineer at Uitenhage Workshops in 1938. After acting as Mechanical Engineer for a year, he was appointed, in 1939, Locomotive Superintendent, Eastern Transvaal System.

During the second World War, as Officer of the South African Engineer Corps, he served in North Africa and in his own country. For his war services, he was made an O.B.E.

In October, 1943, Mr. Ward Smith returned to the South African Railways as Locomotive Superintendent, Eastern Transvaal System. From September 1945 to January 1946, he acted as Chief Superintendent (Motive Power), and, later in that year, he was appointed Advisory Engineer to the South African Railways and to the Office of the High Commissioner for South Africa in London. He returned to South Africa to take up the position of Assistant Chief Stores Superintendent, S.A.R. in 1949, subsequently becoming Assistant Chief Mechanical Engineer (Motive Power), the appointment he held until his retirement.

Mr. WARD SMITH was elected a member of the Permanent Commission of the International Railway Congress Association in July 1946. He took part in the Lucerne Congress (1947) as representative of the South African Railways and gave up his mandate in 1949, when he returned to South Africa. In spite of his short stay amongst us, he showed always great interest in our works and did his best to associate the great railway system of South Africa with the achievements of our Association.

We offer his family our sincere condolences.

THE EXECUTIVE COMMITTEE.

NEW BOOKS AND PUBLICATIONS.

[**385** (06 (6)]

Second conference of General Managers of Railways in Southern Africa. Record of Proceedings. Nairobi, 21st to 25th November 1955. — One volume (7 7/8 × 12 1/2 in.) of 154 pages.

The conference was attended by delegates from eight railways extending from the South African Railways and Harbours in the south to the Congo Railways in the north. It was held at Nairobi, administrative headquarters of the East African Railways and Harbours, the General Manager of whom, Mr. A. F. KIRBY, was the Chairman.

The first session of the Conference was held the year before in Johannesburg, and it was decided to organise a third at Victoria Falls, so that the institution tends to become a permanent one as the results have been so valuable for the railways participating.

As a result of the experience acquired, the number of questions was restricted but all the same they totalled twenty-four. Some related to the railways, others to the working of the harbours. Some of them had already been discussed at Johannesburg and were included again on account of new developments, whilst all the questions were the subject of notes communicated by the Administrations able to supply any instructive information.

The most divers aspects of the railway were considered during these discussions: operating methods and signalling, traction engines, the constitution and maintenance of the permanent way, the prevention of accidents, standardisation of rolling and traction stock, roller bearing axle boxes, the gauge of the 3′ 6″ track, refrigeration methods in wagons and coaches, the construction and working of goods depots, commercial questions, and road transport.

As regards the working of the harbours, the companies concerned endeavoured to determine the capacity as regards reception and consignment, as well as the traffic perspectives in order to be in a position to draw up extension projects. The equipment of the harbours and handling methods, warehousing possibilities, the design of the store sheds were amongst the other questions examined.

This volume gives the complete records of the working sessions of the Conference. It is pleasant to read on account of the conciseness and objectiveness of the discussions. At the beginning of the book there is a brief summary of the conclusions adopted and decisions arrived at. One is left with an impression of close collaboration and the general desire to let all the members profit by the experience and results of the studies made by each one.

The Conference has no permanent representative organisation. The function of secretariat has been assumed until the next Session by the Management of the railway where the Conference was held, in this case the East African Railways and Harbours whose headquarters are at Nairobi.

E. M.

[**625** .13 (45 + 494)]

Il Cinquantenario del traforo del Sempione 1906-1956. — *(The fiftieth anniversary of the Simplon tunnel 1906-1956).* — A pamphlet (8 3/4 × 11 1/2 in.) of 34 pages, with many illustrations and three tables, 1956. — General Management of the Italian State Railways, Piazza della Croce Rossa, Rome.

The General Management of the Italian State Railways has published a small book devoted to the Fiftieth Anniversary of the opening of the Simplon railway line.

It was, in fact, on the 1st June 1906 that the tunnel was opened to regular services, which gave rise to magnificent inauguration ceremonies presided over by King Victor-Emmanuel III and the Swiss President Louis Forrer.

The said pamphlet consists of two parts: the first, by Mr. Livio **JANNATONI** is historical in scope; the second, written by Dr. Luigi **MAGLIETTA**, deals with the technical problem.

These articles were also published in the *Ingegneria Ferroviaria,* No. 5, May 1956.

In his historical review, Mr. Jannattoni recalls the ideas current from the time of the Romans till the epoch of Chevalier Kaspar de Stockalper of Brigue who obtained concessions from Milan for the transport of goods via the Simplon route, then a purely commercial route.

Then there was the Napoleonic route, a route of strategic importance above all. This new route started from Brigue and ran over the Simplon peak to Domodossola.

The report is copiously illustrated, and finally after considerations on present day railway traffic, ends with a study of the technical achievement.

This begins by giving the characteristics of the layout, the choice of which was long debated.

It is known that as far as the transport of spoil and the running off of the water were concerned, the base gallery adopted for the Simplon is definitely better than the top gallery.

There was also the fear that in driving a tunnel through the Simplon, high temperatures of the order of 50° would be met with.

Geological studies made it possible to determine the nature of the rocks.

Rotating hydraulic drills of the Brandt type solved the problem of carrying out the work within acceptable time limits.

The report also goes into this subject at length as well as the question of ventilation.

Two longitudinal galleries were drilled, connected together by cross galleries, which facilitated transport and ventilation.

The renewal and cooling of the air in the galleries meant that the men did not suffer from the high temperatures of 50° and over in which they had to work.

One great difficulty was the inrush of water, both hot and cold; the thrust of the enclosing ground also made special precautions essential: the timbering had to be replaced by metal framework which often led to a slowing down of the progress of the work.

Some very clear plates are included in the study, which make it possible to follow without difficulty the technical commentary on the work without having to have a thorough knowledge of the Italian language.

In reading this pamphlet issued by the General Management of the Italian State Railways, we appreciate the boldness of those who undertook this work, the efforts and sufferings that went to its completion (miners and engineers) and the perseverance needed to achieve this notable work in railway annals.

J. D.

[**385** (09 .3 (45)]

LE FERROVIE ITALIANE DELLO STATO, 1905-1955. *(The Italian State Railways*, 1905-1955*).* — Special edition published on the occasion of the Fiftieth anniversary. — One brochure (11 3/4 × 8 in.) of 88 pages, with numerous illustrations and plates. — 1956, Roma, published by the General Management of the Italian State Railways, Piazza della Croce Rossa.

In April 1905, the law instituting the Administration for running the railways by the Italian State was passed. On the 1st July of that year, the F. S. took over the lines operated till then by three concession-holding companies. The system henceforward to be operated directly by the State extended to 10 557 km (6 560 miles). In 1906, by the amalgamation of other lines, it reached 13 074 km (8 123 miles).

The object of this book is to give the history of the fifty years that have elapsed since the unification of the railways in Italy.

The author distinguishes five periods in the evolution of the railway during this half century: from 1905 to 1915 amalgamation and organisation; from 1915 to 1922 the upheaval of the first world war; 1923 to 1939 development, reinforcement and consolidation; 1939 to 1945, further upsets due to the war; 1946 to 1955, reconstruction and modernisation. He characterises each of these periods in an introductory note, giving the progress realised. The most striking facts are already mentioned in the introductory note by the General Manager, M. Giovanni DI RAIMONDO, Engineer.

In the rest of the book, all the various aspects of a railway undertaking in the widest sense are dealt with: the layout of the lines, the permanent way, the bridges, the tunnels, the stations, the production and utilisation of electric power, electric traction, signalling and telecommunications, the traction and rolling stock, the ferry services across the Straits of Messina, the activities of the Research Institute, the progress of the traffic, the timetables, the staff, and all the supplementary institutions.

As it is impossible to quote all that has been done to make a railway system remarkable from so many points of view, we must of necessity limit ourselves to a certain selection.

In the first few years, 2 000 km (1 240 miles) of new lines were built. Then came the through Rome-Naples and Florence-Bologna lines.

The central stations of Milan, Florence and finally Rome are examples of rational design.

The permanent way has been reinforced and maintenance methods modernised. Numerous bridges and viaducts have been rebuilt to take the new loads and increased speeds. Important new tunnels have been made, in particular that of Vernio, which is 18.5 km (11.5 miles) long, on the « Direttissima » between Florence and Bologna. The electric power requirements for traction in particular are met to a large extent by power stations belonging to the F. S. having a total power of 271 500 kVA.

As regards safety, mention must be made of the use of the automatic block, numerous central control posts for working the points and signals by means of route levers.

The most striking innovations concern the rolling stock. The most recent steam locomotives, electric locomotives and electro-trains and electro-railcars have profoundly modified transport technique. Thermal railcars offer new possibilities in the case of passenger services.

In both passenger and freight traffic, there has been a considerable increase, particularly during the last few years.

This book gives us a picture of a railway equipped and operated on very modern lines, and able to cope with all the requirements of a very varied clientele.

E. M.

[**385** (09 (45)]

La Gestione di Stato delle Ferrovie Italiane (1905-1955). Monografie. *(The running of the Italian Railways by the State (1905-1955). — Monographs.)* — Work drafted by the Information Section of the Staff and General Affairs Dept. of the F.S. — One volume (7 7/8 × 10 3/4 in.) of 488 pages, numerous illustrations and maps. — 1956, Roma, Officine Grafiche "Appollon", via Tiburtina, 1292.

Recently the Management of the Italian State Railways published a book devoted to the celebration of the fiftieth anniversary of the setting up of the State Administration to run the amalgamated Italian lines.

This present work has been written with the same object, but on a larger scale, to give a complete picture of the work achieved since 1905.

It contains a series of monographs prepared by specially qualified authors, each dealing with one particular aspect of the railway.

In an introductory note, the General Manager, Mr. Giovanni DI RAIMONDO, Engineer, gives a brief history of the formation of the F. S., marks the main stages of their development, recalls the dramatic events which subjected them to a severe testing, and characterises the present situation from the double point of view of rolling stock and economics.

The actual monographs are preceeded by a note about the historical figure of the first General Manager, the Engineer Riccardo BIANCHI. Well known in the railway world on account of his invention of hydrodynamic equipment for operating points and crossings, this eminent engineer also carried out an immense task in unifying and organising the F. S., and afterwards in perfecting the technical equipment of the railway. Under his management the three phase electric traction installations of the Valteline were carried out, followed by other remarkable applications.

The monographs deal with the most varied subjects. In a first group can be included :

the Legal Structure of the State Railways;
Operating methods;
the Transport of passengers;
the Freight Services;
the Tariff Policy and State control of the F. S.

Then there are those of a more technical character describing the evolution that has taken place during these fifty years in the electric locomotive :

bridges;
the production of electric power and the transmission lines;
signalling and safety.

In the case of the general services, which can have such a great influence upon the operating, the authors have stressed :

Social activities and welfare;
the Research Services;
the Health Services;
Accountancy Services;
Stores.

Complicated problems have arisen in two regions of Italy. Readers will learn with interest how international events have affected the plan of the lines serving the port of Trieste, and again how the F. S. have been able to adapt the lines of the Trentin-Upper Adige to the requirements of both local and international traffic.

This book contains a complete history of the great changes made to the Italian Railway system during the last half century, and shows at the same time to what a state of perfection the F. S. Administration has brought the railway system under their management.

E. M.

[**385** (08 (460)]

RED NACIONAL DE LOS FERROCARRILES ESPAÑOLES. — **Memoria del Consejo de Administración. Ejercicio 1955.** *(Spanish National Railways. — Report of the Administrative Council. Year 1955).* — One volume (8 1/4 × 12 1/4 in.) of 148 pages, with numerous illustrations and tables. — 1956, Madrid, Sucesores de Riradeneyro, S.A., Pasco de Onesimo Redondo, 26.

Like the previous reports, this one begins with a preliminary note giving the main outlines of the activities of the railway during the year 1955. Detailed information is then given in the chapters dealing with the various departments.

Passenger traffic was slightly greater than in 1954. On the other hand, there was a certain decline in freight traffic.

The operating receipts, which are analysed in Chapter II, increased slightly, due partly to the better tariffs which were in force during the whole of this year whereas they were only applied over a part of 1954.

Operating costs increased considerably. The headings showing an increase were: staff (though the actual number of employees was reduced), coal, wood, electric power. There was also an increase in train costs and intensified maintenance of the permanent way. The operating coefficient was 118 %.

The actual working is the subject of Chapter I. The train services (train services and traffic), purchases, staff, social activities for the staff are the main subdivisions. The tonnes-kilometres hauled increased as a whole by 4.91 %.

Chapter III lists the improvements made to the permanent way and rolling stock. The latter benefited by the purchase of a considerable number of electric and Diesel locomotives.

Amongst the numerous reconstructions and improvements mentioned in Chapter IV is the putting into service of 110 km (68 miles) of electrified lines, part of the general electrification programme.

Chapter V is devoted entirely to the use made by the R. E. N. F. E. of the credits at its disposal according to the agreement made in September 1953 between the Governments of the United States of America and Spain for mutual defence aid, as well as various technical measures of assistance.

Other chapters deal with the forestry undertakings from which the R. E. N. F. E. obtains the greater part of its sleeper requirements; the legal position of road transport and the operating of the lines conceded to the R. E. N. F. E. (operated directly or by contract); and finally with the charges borne by the railway under the form of taxes and contributions of various kinds.

This report leaves one with the feeling that the R. E. N. F. E. is making constant progress. On the credit side for 1955 must be noted, taking only the principal points, extensions to and successful improvements in the train services, better user of the stock, an increase in the number of traction units, important increases in the signalling equipment, and the strengthening and improving of the permanent way.

E. M.

[**385** (09 .3 (675)]

Compagnie du Chemin de fer du Bas-Congo au Katanga, 1906-1956. *(Lower Congo to Katanga Railway Company, 1906-1956).* — One volume (9 × 11 1/2 in.) of 200 pages, with numerous illustrations and maps. — Published by the « Compagnie du B.C.K. », 7, rue Montagne du Parc, Bruxelles. — 1956, Brussels, M. Weissenbruch & Co., Ltd, Printers, 49, rue du Poinçon.

Three great undertakings were started almost simultaneously in the Belgian Congo in 1906. These were the High-Katanga Mining Union, the Lower Congo to Katanga Railway Company, and the Congo International Forestry and Mining Company. They have just celebrated their fiftieth anniversary. There is a certain similarity in their beginnings, as will be seen when reading the present book which is specially consecrated to the creation and development of the railway.

Although the actual foundation of the Company only dates from 1906, it is necessary to go much further back to discover the far off beginnings. Closely bound up with the general history of the Belgian Congo, this fecund conception first saw the light of day in the midst of extremely complex political, geographical and economic circumstances. Chapter I is devoted to recapitulating the genesis of the Colony and its main lines of communication.

With Chapter II, we enter the period of reconnaissance and investigations. This is concentrated on relating the perilous missions to fix the general line of the track. Preconceived ideas and opposing views on the essential object of the railway were fuel to the quarrel about the routes.

As from 1922, the promotors had the satisfaction of seeing their project enter into the phase of actual realisation. Chapter III describes the difficulties of all kinds which the final studies and the actual construction came up against. In 1928, the line was completed and was inaugurated in the presence of the King and Queen of Belgium. This was the occasion when homage was paid to the pioneers and chief actors in this adventure which often proved dramatic.

Going back to the preliminary work, Chapter IV gives details about the various missions and studies, and the determination of the layout of both the main line and its connections with other railways in the west, south and north of the colony. It also gives the characteristics of the lines operated by the B. C. K., and details about the traffic and traction problems.

In the *conclusion,* the authors show how, besides its statutory objectives, the railway had an excellent influence upon the regions it runs through by favouring their economic development.

A *supplement* gives details about various railway Societies which also contribute to the economic development of Katanga. Additional access to the Atlantic was obtained by a branch line linking up the Benguela Railway to Dilolo. This line was inaugurated on the 1st July 1931.

The book is magnificently illustrated. Coloured maps make it easy to follow the various stages in the construction of the railway lines. Various photogravures show life in Africa and the new activities to which the railway has given birth. Others show the men who played a notable part in the history and creation of the great undertaking which has become the B. C. K.

E. M.

[**385** (08 (59)]

HARRISON (C.G.), M. Inst. T., M. I. Mech. E., M. I. I. A., General Manager, Malayan Railway. — **Malayan Railway Administration Report for the year 1955.** — 1956, Kuala Lumpur, Charles Grenier & Co., Ltd. — One brochure (8 1/4 × 13 in.) of 87 pages, with numerous illustrations and maps.

With a total development of 1 028 miles the Malayan Railway consists of two main lines. One leaves Singapore and runs along the west coast to the frontier of Thailand in the north, serving the plain between the sea and the chain of mountains that cuts the peninsula longitudinally. There are branch lines from this main line to the various ports, the chief of which is that of Swettenham. The east coast line leaves the other line 137 miles beyond Singapore and runs northwards to the China Sea. Just before the terminus, it is linked up with the Thailand system by a branch line.

Nearly all this railway is single track. The rails are laid to metre gauge (3′ 3 3/8″) on wooden sleepers 1.98 m (6′ 6″) long, and 25 by 12.5 cm (9 7/8″ and 4 3/4″) square. Flat bottomed rails B. S. S. (British Standard Specifications) of 40 kg/m (88 lbs) on the main lines and 30 kg/m (66 lbs) on the branch lines and sidings are used. The usual gradient is 10 ‰, except on a small section where it reaches 12.5 ‰.

Apart from these brief indications, the introductory note also deals with the climate, the population, and the chief products, natural rubber and tin.

Chapter I, Finances, notes with satisfaction that the receipts reached a new record figure, these results being due to both kinds of traffic, freight and passenger. Operating costs also increased but to a much smaller proportion. However, at the end of the year, there were indications that in the year 1956 an increase in wages and the cost of various materials would have to be faced.

Under the title « General Aspect », Chapter II comments on the activities of the passenger and freight services and the revised tariffs due to road competition. Various modernisation measures are in hand or under consideration. The promotion of Malayan employees to managerial posts presents certain difficulties which the management is endeavouring to solve.

The twelve chapters which follow deal with the working of all the departments and the position as regards the installations and stock. Speed trials have shown that the timetables could be improved by increasing the speed to 60 miles an hour on the main line provided certain alterations were made to the track and the signalling.

The last part of the report contains very detailed numerical tables dealing with the receipts and costs compared with those of the previous year and showing the present position of the undertaking from both the material and financial points of view.

The Malayan Railway continues to increase in prosperity. The harbours and railway lines have both contributed to these favourable results. These results, together with the new increases in traffic expected, justify important capital investments.

E. M.

Centenary of the Revue Universelle des Mines (R. U. M.).

(May 6, 7 and 8, 1957).

The « Association des Ingénieurs sortis de l'Ecole de Liège (A. I. Lg.) » organize important celebrations to commemorate the centenary of its scientific publication : « La Revue Universelle des Mines ».

On this occasion, a Congress will take place on the subject : « Scientific Research and Industry », and will include some Belgian Days, during which eminent specialists will submit reports on the organization and the aim of the researches made in Belgium and in the Belgian Congo in connection with the following : Coal, Chemistry, Electricity, Nuclear Power, Engineering, Ore and Metals, Metallurgy and Mechanics.

In addition, International Days will be honoured by the presence and collaboration of eminent personalities from France, Germany, Great Britain, Holland and Switzerland.

Further information may be obtained by applying to the « Association des Ingénieurs sortis de l'Ecole de Liège, 22, rue Forgeur, Liège (Belgique) ».

M. WEISSENBRUCH & Co. Ltd.
Printer to the King
(Manag. Dir.: P. de Weissenbruch,
238, chaussée de Vleurgat, XL)
Edit. responsible : P. Ghilain

PRINTED IN BELGIUM